NASA Contractor Report 177343 - VoL - 2

Propulsion and Airframe Aerodynamic Interactions of Supersonic V/STOL Configurations

Volume II: Wind Tunnel Test Force and Moment Data Report

D.E. Zilz

NASA

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FORFWORD

This report was prepared by McDonnell Aircraft Company (MCAIR), a component of McDonnell Douglas Corporation, St. Louis, Missouri, for the National Aeronautics and Space Administration, Ames Research Center. The study was performed under NASA Contract NAS2-10791, "Propulsion and Airframe Aerodynamic Interactions of Supersonic V/STOL Configurations". The work was performed from October 1980 through September 1985 with R. O. Bailey as the NASA ARC Technical Representative. The program was accomplished under the direction of P. E. Hiley, Program Manager and H. W. Wallace, Technical Study Manager.

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This report was submitted in four volumes by the authors in September 1985.

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LIST OF ILLUSTRATIONS

LIST OF ABBREVIATIONS AND SYMBOLS

Symbol	Definition
A/B	Afterburning power setting on nozzle
A_c	Inlet capture area ($35.23 cm^2$)
AF	Axial Force
A_o	Total inlet captured stream tube area (cm^2)
ALBEN	Aerodynamically Load Balanced Exhaust Nozzle
ALPHA, ALPHAM	Model angle of attack (Deg)
A_{TH}	Nozzle throat area
b_c	Model canard span (52.49cm)
b_w	Model wing span (130.30cm)
B.L.	Model butt line
$\bar{c}_c$	Mean aerodynamic canard chord (19.60cm)
CD	Total aircraft drag coefficient (CDA + CDNOZ)
CDA	Metric airframe drag coefficient
CDNOZ	Exhaust nozzle drag coefficient (2 nozzles)
CL	Total aircraft lift coefficient (CLA + CLNOZ)
CLA	Metric airframe lift coefficient
CLNOZ	Exhaust nozzle lift coefficient (2 nozzles)
CM	Total aircraft pitching moment coefficient
CMO	Total aircraft pitching moment coefficient at zero lift
CMA	Metric airframe pitching moment coefficient
CMNOZ	Exhaust nozzle pitching moment coeeficient (2 nozzles)
CMCRB	Canard root bending moment coefficient ($MCRB/(S_c b_s Q)$)
$\bar{c}_w$	Mean aerodynamic wing chord (41.70cm)
C_p	Pressure coefficient [$(P_L-P_o)/Q_o$]

LIST OF ABBREVIATIONS AND SYMBOLS (CONTINUED)

Symbol	Definition
CMAPS	Compact Multimission Aircraft Propulsion Simulator
DELCR	Right hand canard deflection angle, positive leading edge up (Deg)
DELCL	Left hand canard deflection angle, positive leading edge up (Deg)
DPDS	Static pressure differential across inlet duct seal
Dry	Dry power setting on nozzle
ES	Engine station
F/T, FT	Flow-Through test mode
FS	Fuselage Station
J/E, JE	Jet-Effects test mode
Mach, M	Free stream Mach number
MCAIR	McDonnell Aircraft Company
MCRB	Canard root bending moment
MFR, MFRA	Average of left and right Inlet Mass Flow Ratios based on calibration correlated to CMAPS turbine exit pressure for Simulator Mode or at nozzle exit chokes for Flow-Through Mode, $[A^o/Ac]$
MS	Model Station
N	CMAPS Rotor speed (RPM)
NPR, NPRA	Average of left and right Nozzle Pressure Ratios $[P_{T_J}/Po]$
NRP	Percent of sea-level referenced design rotor speed, $(N/75185) \times \theta \times 100)$
P, Po	Free Stream static pressure
P2	Average static pressure at compressor face
P_L	Local Static Pressure

Symbol	Definition
Plane 2	Compressor face
Plane 4	Turbine inlet
Plane 8	Exhaust Nozzle Duct
Plane 15	Compressor discharge
Plane 57	Turbine discharge
PS57	Turbine discharge static pressure
P_T, P_{T_O}	Free stream total pressure
P_{T_2}	Average total pressure at compressor face, left or right
P_{T_8}	Average total pressure at exhaust nozzle
$P_{T_{max}}$	Maximum value of total pressure of compressor face
$P_{T_{min}}$	Minimum value of total pressure at compressor face
P_{T_J}	Total pressure of jet exhaust at nozzle exit
Q, Q_o	Free stream dynamic pressure
R_____	"R" preceeding any parameter indicates Reference value for all points in a given run; usually the value measured at $\alpha = 0°$
REC1R	Total pressure recovery at right hand compressor face, $[P_{T_2}/P_{T_O}]$
SIM	Simulator test mode
T_{T_2}	Total Temperature at Plane 2
T_{T_8}	Total Temperature at Plane 8
W2	Inlet Mass Flow Rate
W8	Nozzle Mass Flow Rate
WL	Model water line
WTAP	Mass Flow function ($WB \sqrt{TT8}/(PTB*A_{TH})$

LIST OF ABBREVIATIONS AND SYMBOLS (CONCLUDED)

Symbol	Definition
α	ALPHA
θ	Sea-level standard day temperature correction $\sqrt{((T_{T_2} + 460)/518.67)}$
δc	DELCR or DELCL
δf	Wing flap deflection angle, positive trailing edge down (Deg)
δn	Nozzle thrust vectoring angle, positive trailing edge down (Deg)

SUMMARY

A wind tunnel model of a supersonic V/STOL fighter configuration has been tested to measure the aerodynamic interaction effects which can result from geometrically close-coupled propulsion system/airframe components. The approach was to configure the model to represent two different test techniques. One was a conventional test technique composed of two test modes. In the Flow-Through mode, absolute configuration aerodynamics are measured, including inlet/airframe interactions. In the Jet-Effects mode, incremental nozzle/airframe interactions are measured. The other test technique is a propulsion simulator approach, where a sub-scale, externally powered engine is mounted in the model. This allows proper measurement of inlet/airframe and nozzle/airframe interactions simultaneously.

Comparison of the measured aerodynamic characteristics between the two test techniques is a direct indication of the extent to which inlet and nozzle flowfields are coupled together. If significant coupling does exist, there will be disagreement between the two data sets. The simulator test technique may then be required in the future to properly measure the aerodynamic characteristics of compact fighter configurations.

Measurement of these propulsion/airframe interaction effects was carried out in a three phase experimental program, sponsored by the NASA-Ames Research Center. Conceptual model design was accomplished in Phase 1, detailed model design and fabrication in Phase 2, and high speed testing in Phase 3.

The aerodynamic configuration tested was a canard/wing concept designed for high transonic maneuverability, employing non-axisymmetric, vectorable exhaust nozzles located near the wing trailing edge.

The overall character of the aerodynamic flowfield, including the interactions due to inlet/nozzle coupling, were quantified by comparing force balance data between the different test modes, and by comparing static pressure distributions over the entire model surface. The purpose of this Volume II report is to document the basic force and moment data in detail. The Volume I report documents the pressure data, Reference 1. All of the analysis for both pressure and force and moment data is presented in the Volume III Test Analysis Report, Reference 2.

1. INTRODUCTION

Many of the configurations proposed for advanced supersonic V/STOL aircraft are very compact in nature. This results primarily from the design goal to minimize control forces and forward lift engine size by concentrating the major components of the aircraft near the center of gravity. Integration of the propulsion system with the airframe for these configurations can result in potentially significant aerodynamic flowfield interactions. These interactions may arise from geometrically close-coupled inlet/nozzle arrangements arising from minimum length nacelles. The problem can be further complicated if the configuration includes movable canards and vectorable nozzles located near the wing.

The data obtained with conventional wind tunnel test techniques can be questionable in the presence of large flowfield interactions, since these techniques cannot achieve simultaneous simulation of all of the flowfields involved. Proper simulation can be achieved with the compact Multi-Mission Aircraft Propulsion Simulator (CMAPS), developed by the Air Force Aeropropulsion Laboratory (AFAPL), Reference 3. The CMAPS, Figure 1-1, is a miniature, low bypass ratio turbofan engine powered by a high pressure air turbine.
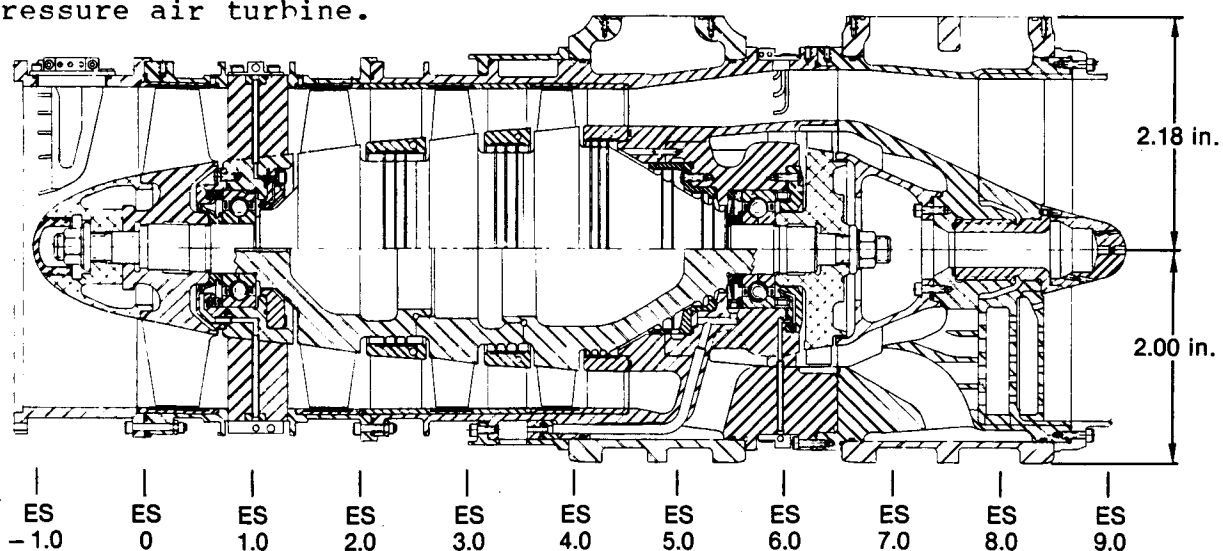
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Figure 1-1. Compact Multimission Aircraft Propulsion Simulator (CMAPS)

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The most beneficial application of the CMAPS will obviously be on those aircraft that have potentially large flowfield interactions between the inlet, nozzle, and airframe. Since testing a CMAPS equipped model may be more complex than testing a conventional model (Flow-Through and Jet-Effects), the need to identify the types of configurations which require CMAPS evaluation is critical. An aerodynamically close-coupled V/STOL configuration represents an effective means of evaluating the requirement for simultaneous inlet and exhaust nozzle flow simulation, and thus the potential need for the CMAPS testing technique.

Based on the foregoing considerations, a three phase NASA program was initiated in October, 1980 to measure airframe/propulsion system interactions of close-coupled supersonic V/STOL configurations. Both propulsion simulator and conventional model techniques were used. An equally important objective was to continue development of installation and test techniques for wind tunnel models equipped with propulsion simulators. This program represented the first time that twin CMAPS had been tested in a wind tunnel model of a full configuration aircraft. Previous programs have tested only single simulators in simple body/nacelle models, Reference 4.

The approach to accomplish these objectives was to design, fabricate, and test two model configurations characterized by close-coupled airframe/propulsion arrangements, each in simulator and conventional test modes. Key characteristics of the two test configurations are shown in Figure 1-2. The external airframe components of the basic model were provided by the Air Force. This basic configuration was developed under prime contract to the Air Force Wright Aeronautical Laboratories (AFWAL) by MCAIR in the Advanced Nozzle Concepts (ANC) program, Reference 4. The alternate configuration is a derivative of the basic configuration with the inlet/nozzle length shortened and the canard removed. At this time, only the basic configuration has been tested. However, the hardware has been fabricated to model the alternate configuration.

2

Basic Design   **Alternate Design**
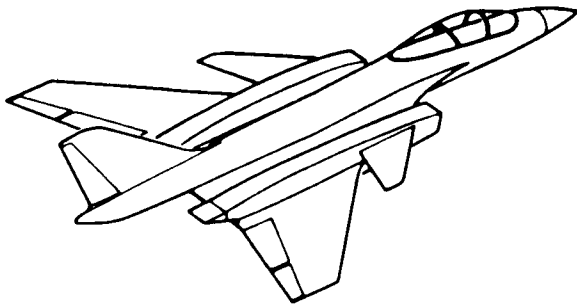
Air-to-Air Concept
- 2-D ALBEN Vectorable Nozzles (AR 4)
- 2-D Normal Shock Inlet With Droop Lip
- Wide-Spaced Podded Nacelles
- Close-Coupled, All Movable Canards
- Advanced Maneuvering Wing
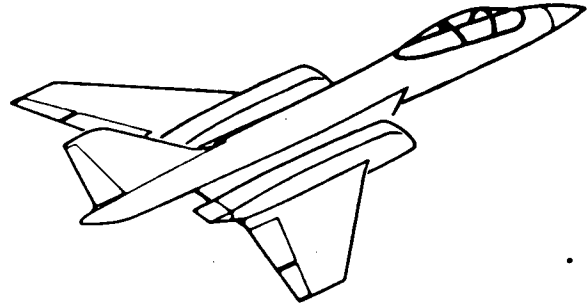
Changes for Alternate
- Round Short Inlet With Lower Slot
- Canards Removed
- Inner Wing Extension Shortened

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Figure 1-2. Aerodynamic Characteristics of Study Concepts

Conceptual design of the test model was completed in Phase 1 during the first seven months of the program, Reference 5. Detailed design and model fabrication were accomplished in Phase 2, as reported in Reference 6.

The results of the Phase 3 wind tunnel tests and analysis are presented in a series of four NASA Contractor Reports (CRs). The pressure data is reported in Volume I of the Wind Tunnel Data Report, (Reference 1). The force and moment data and data reduction procedures are reported in this document, Volume II. The detailed data analysis and executive summary are presented in the Test Analysis Report and Final Report, respectively (References 2 and 7).

The following sections include a description of the test article, facility, instrumentation and other data reduction procedures. The force and moment data is presented graphically in Appendix A of this volume.

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2. TEST ARTICLE DESCRIPTION

The test vehicle was a 9.62% scale model of a supersonic V/STOL aircraft with twin, podded engine nacelles. The nacelles incorporated normal shock inlets and vectorable Aerodynamically Load Balanced Exhaust Nozzles (ALBENs), designed by General Electric. The model installed in the NASA-Ames 11x11-ft transonic wind tunnel is shown in Figure 2-1. Testing was performed at speeds from Mach 0.4 to 1.4 and through the angle-of-attack range from -2° to 20°.
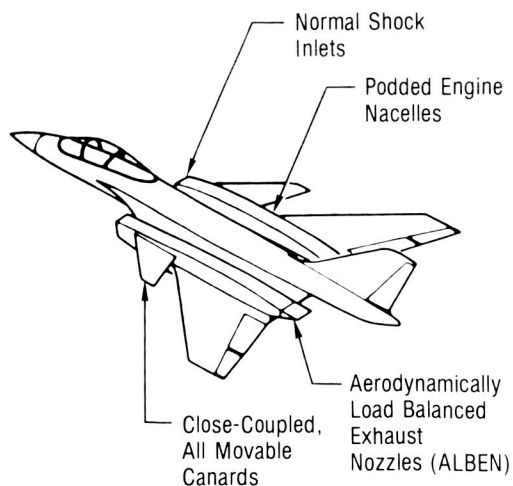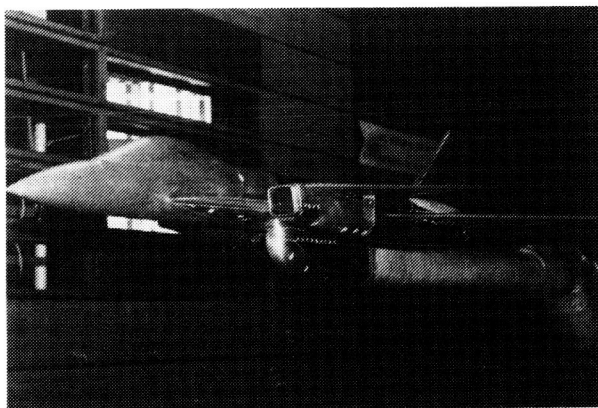
Model Geometry

Fuselage Length:	1.79 m (5.88 ft)
Nacelle Length:	0.86 m (2.83 ft)
Wing Span:	1.30 m (4.28 ft)
Wing Area:	0.48 m² (5.22 ft²)
Canard Area:	0.09 m² (1.02 ft²)
Inlet Capture Area:	35.23 cm² (5.46 in.²)
Nacelle Max Area:	116.14 cm² (18 in.²)
Nozzle Throat Area (Dry):	19.42 cm² (3.01 in.²)
Nozzle Throat Area (A/B):	33.23 cm² (5.15 in.²)

Labels: Normal Shock Inlets; Podded Engine Nacelles; Aerodynamically Load Balanced Exhaust Nozzles (ALBEN); Close-Coupled, All Movable Canards

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Figure 2-1. Supersonic V/STOL Wind Tunnel Model Installed in NASA-Ames Transonic Tunnel

The model was tested in three different modes: the conventional Jet-Effects and Flow-Through modes, and the propulsion simulator (CMAPS) mode. A schematic of the three modes, each in its characteristic configuration, is shown in Figure 2-2. A common support system and metric arrangement were maintained for all three test modes as shown in Figure 2-3.

Simulator Mode

Flow-Through Mode

Jet-Effects Mode
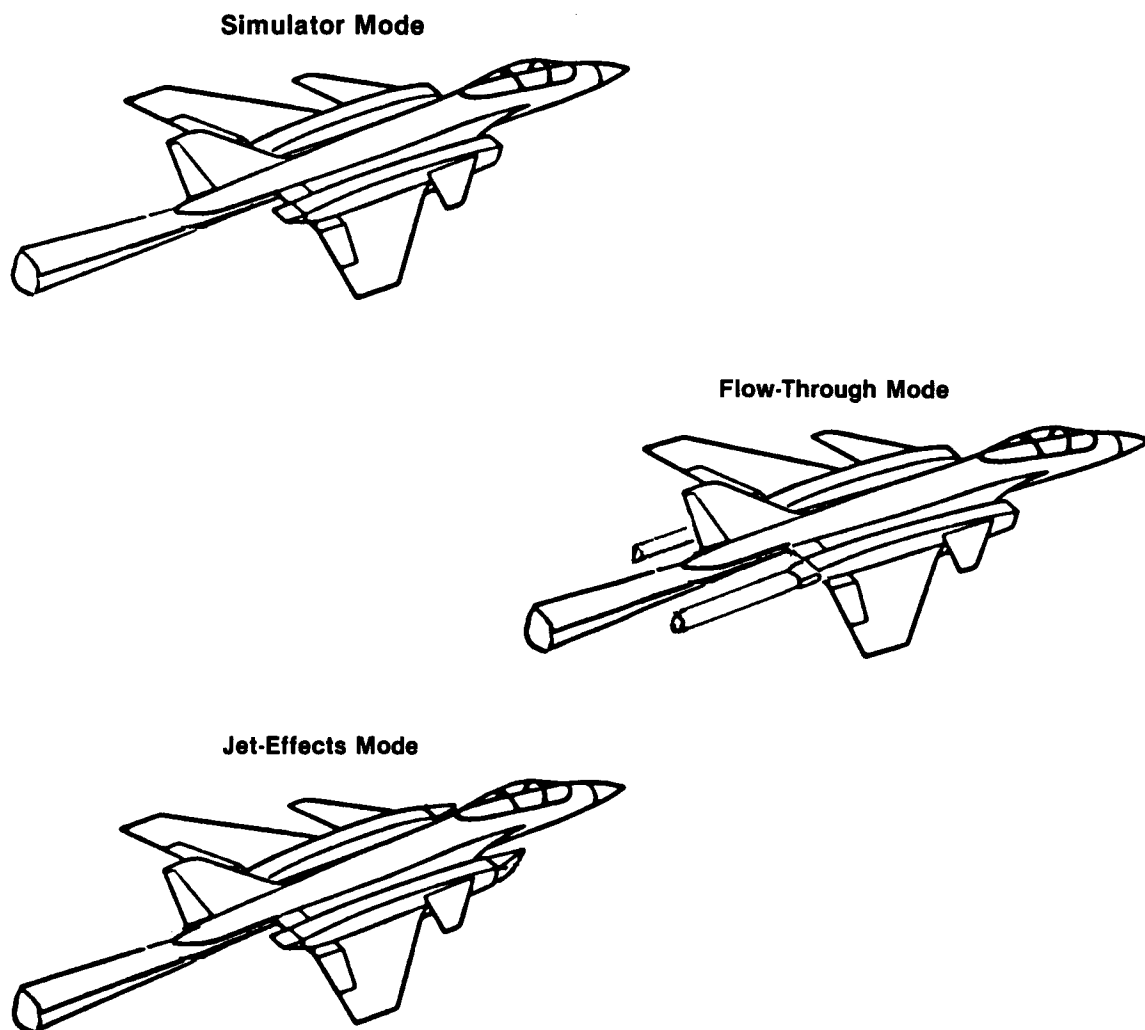
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Figure 2-2. Test Mode Characteristics
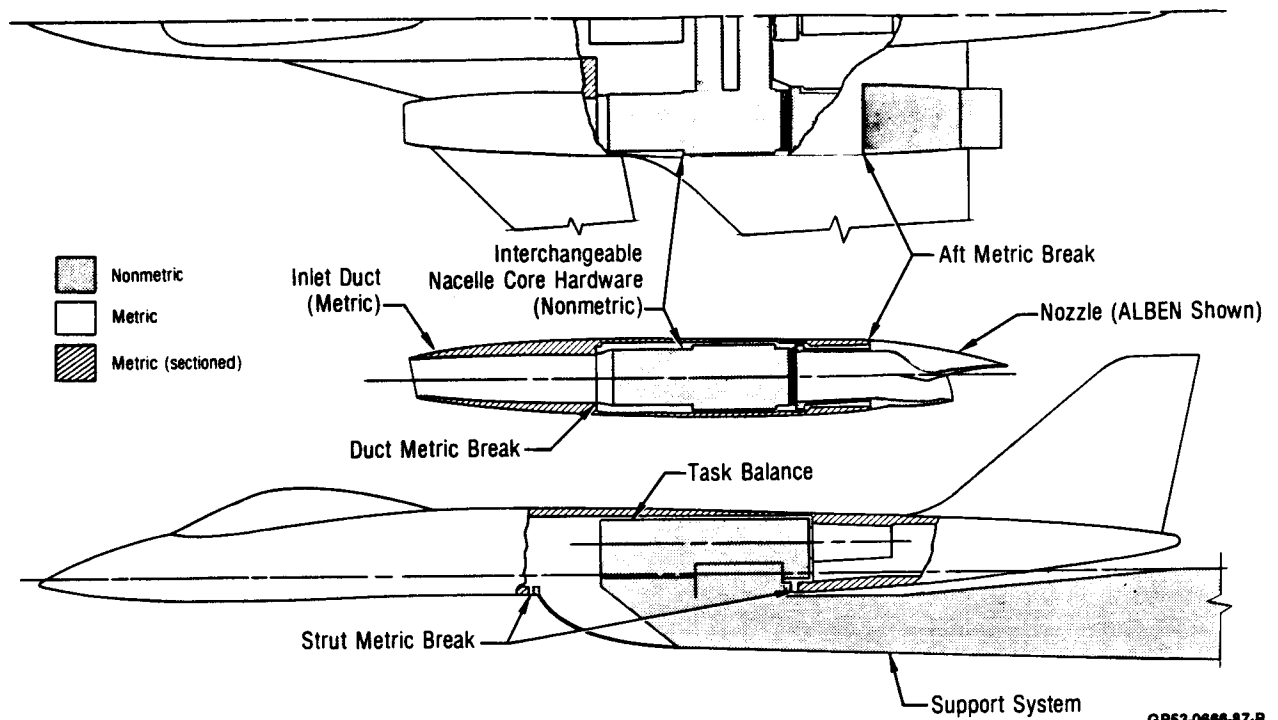
Figure 2-3. Common Support System and Metric Arrangement

Within the three test modes, a matrix of two inlet and two exhaust system configurations was tested. The inlet was configured as either flowing or faired. The exhaust system incorporated either ALBENs or nozzle extension ducts with chokes installed. Four aerodynamically different test configurations were derived from the two inlet and two exhaust configurations. These configurations were termed: 1) Common Baseline, 2) Nozzle Extension, 3) Nozzle Extension Baseline, and 4) Simulated Aircraft. The external differences in these configurations were only in the nacelle geometry, Figure 2-4; all other external model features were common, including canards, wings, and vertical tail, Figures 2-5 through 2-7. A matrix of the modes, inlet/nozzle combinations, and test configurations is shown in Figure 2-8. The Common Baseline configuration was tested in each mode as a tie-in for the three separate model build-ups and used to account for any bias errors created between tunnel entries. The Nozzle Extension configuration used the extension ducts to displace the exhaust plume from the vicinity of the airframe such

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that inlet mass flow ration (MFR) effects could be measured
independent of jet-induced effects. The Nozzle Extension
Baseline configuration was used to account for the effects of the
extension ducts on the metric airframe as compared to the ALBEN
installation. Of the four configurations tested, the Simulated
Aircraft configuration is the best representation of an aircraft
in flight.

Aerodynamic Configurations

Conventional Mode

Metric ← Nonmetric

Common Baseline

— Jet Effects

Nozzle Extension

— Inlet Effects

Nozzle Extension
Baseline

CMAPS Mode

— Nozzle Extension
Effects on Airframe

Simulated Aircraft

**Contribution
to Test Data:**
— Jet Effects
— Inlet Effects
— Coupling Effects

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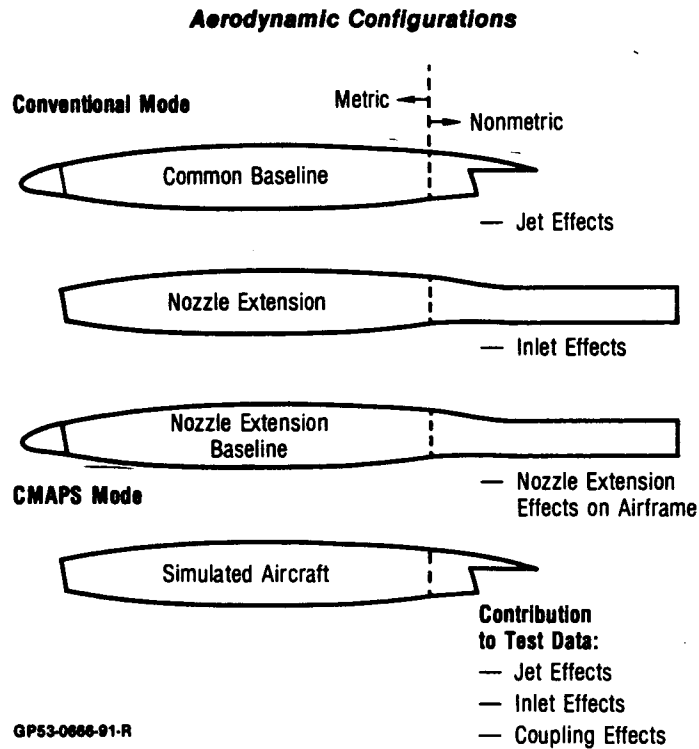
Figure 2-4. Comparison of Test Configuration

Model Geometry
s = 0.0919 m² (0.989 ft²), Exposed
b = 0.5249 m (1.722 ft)
Aspect Ratio = 3.0
τ = 0.25
c_R = 28.000 cm (11.02 in.)
c_T = 7.00 cm (2.76 in.)
MAC = 19.60 cm (7.72 in.)
Λ_{LE} = 45 deg

Airfoil Sections
BL 79.5: NACA 64A006
BL 177.54: NACA 64A003.5

Deflection
δ_c = −20 to 10 deg
δ_c Is Positive for
     Leading Edge Up

FS 31.046

Model Scale

Canard/Nacelle Intersect

BL 6.324

BL 8.379

BL 9.668

Canard/Nacelle
Intersect

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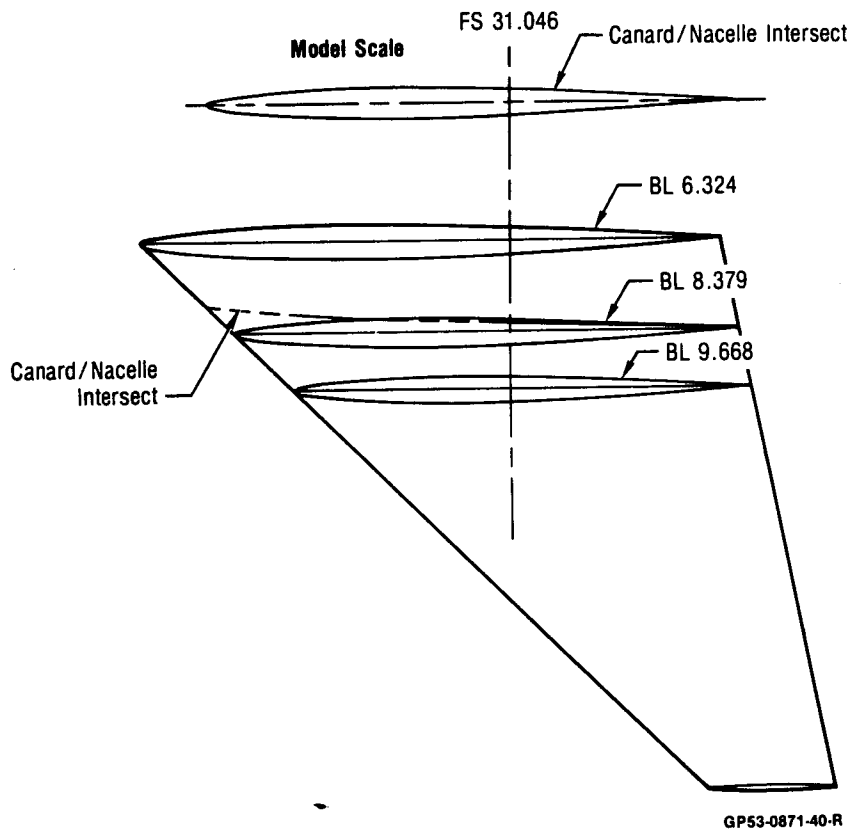
Figure 2-5. Canard Geometry Description

Model Geometry
$s = 0.4851$ m^2 (5.221 ft^2)
$b = 1.3031$ m (4.275 ft)
Aspect Ratio $= 3.5$
$\tau = 0.25$
$c_R = 59.564$ cm (23.45 in.)
$c_T = 14.890$ cm (5.86 in.)
MAC $= 41.697$ cm (16.42 in.)
$\Lambda_{L_E} = 45$ deg

Airfoil Sections
BL 20.000: NACA 64A004.6
BL 41.000: NACA 64A004.6
BL 104.000: NACA 64A005.5
BL 243.350: NACA 64A003.0

Trailing Edge Flaps

21.43 cm
(8.438 in.)

6.40 cm
(2.52 in.)

5.08 cm (2.00 in.)
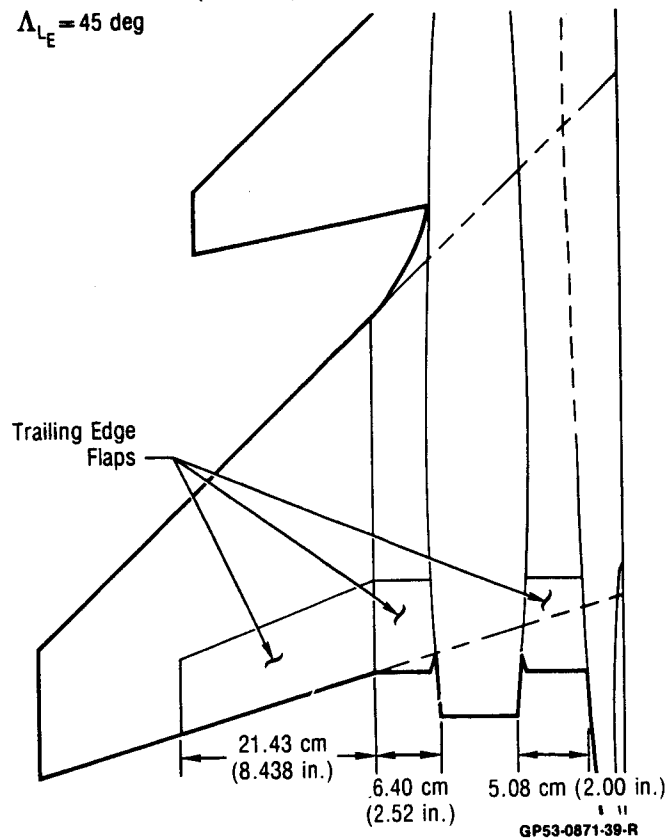
Figure 2-6. Wing Geometry Description

Model Geometry

$s = 0.0630$ m^2 (0.678 ft^2), Exposed
$h = 25.09$ cm (9.88 in.)
Aspect Ratio = 3.5
$\tau = 1.0$
$\lambda = 0.333$
$c_R = 37.64$ cm (14.82 in.)
$c_T = 12.55$ cm (4.94 in.)
MAC = 27.18 cm (10.70 in.)
$\Lambda_{L_E} = 50$ deg

Fuselage/Tail Intersection: NACA64A005.5
Highest Tail Waterline: NACA64A003.5
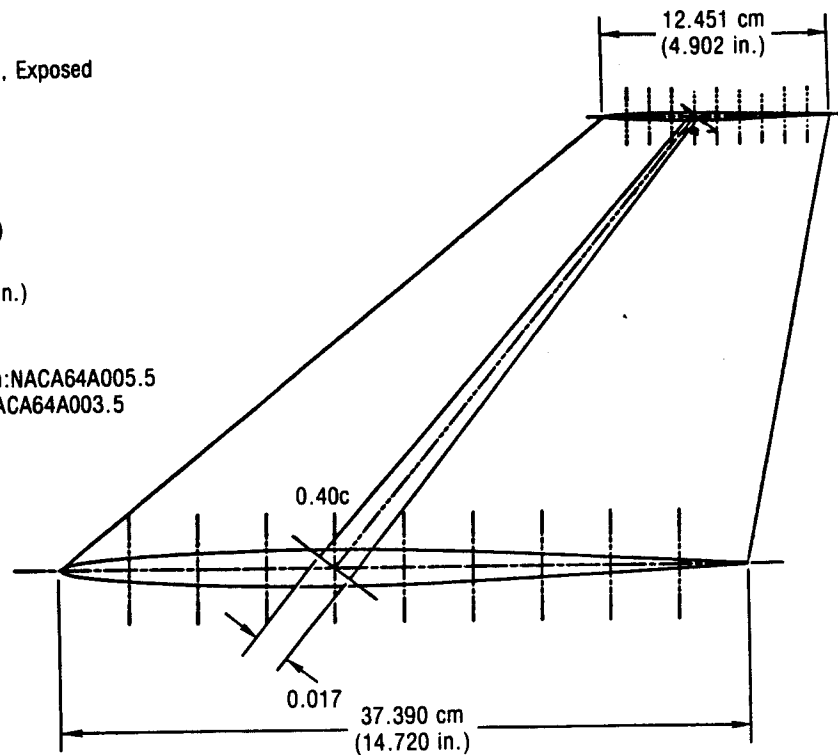
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Figure 2-7. Vertical Tail Geometry Description

Test Configuration	Propulsion System Configuration		Test Mode		
	Inlet	Nozzle	Jet-Effects	Flow-Through	CMAPS
Common Baseline	Faired	ALBEN	X	X	X
Nozzle Extension	Flowing	Extensions		X	X
Nozzle Extension Baseline	Faired	Extensions		X	
Simulated Aircraft	Flowing	ALBEN			X

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Figure 2-8. Inlet/Nozzle Combinations Tested in Each Mode

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2.1   TEST MODES — Each of the three test modes (CMAPS, Jet-Effects, and Flow-Through) represented a different wind tunnel test technique.   A major program objective was to eliminate bias errors due to test technique differences.   Therefore, a common support system and a common metric arrangement were used for all three test modes (Figure 2-3).   The internal flow hardware was unique to each test mode but interchangeable between the three modes, as shown in Figure 2-9.   The flow path through the nacelle could be changed by installing a simulator, a jet-effects plenum, or a flow-through duct, depending on the test mode desired.
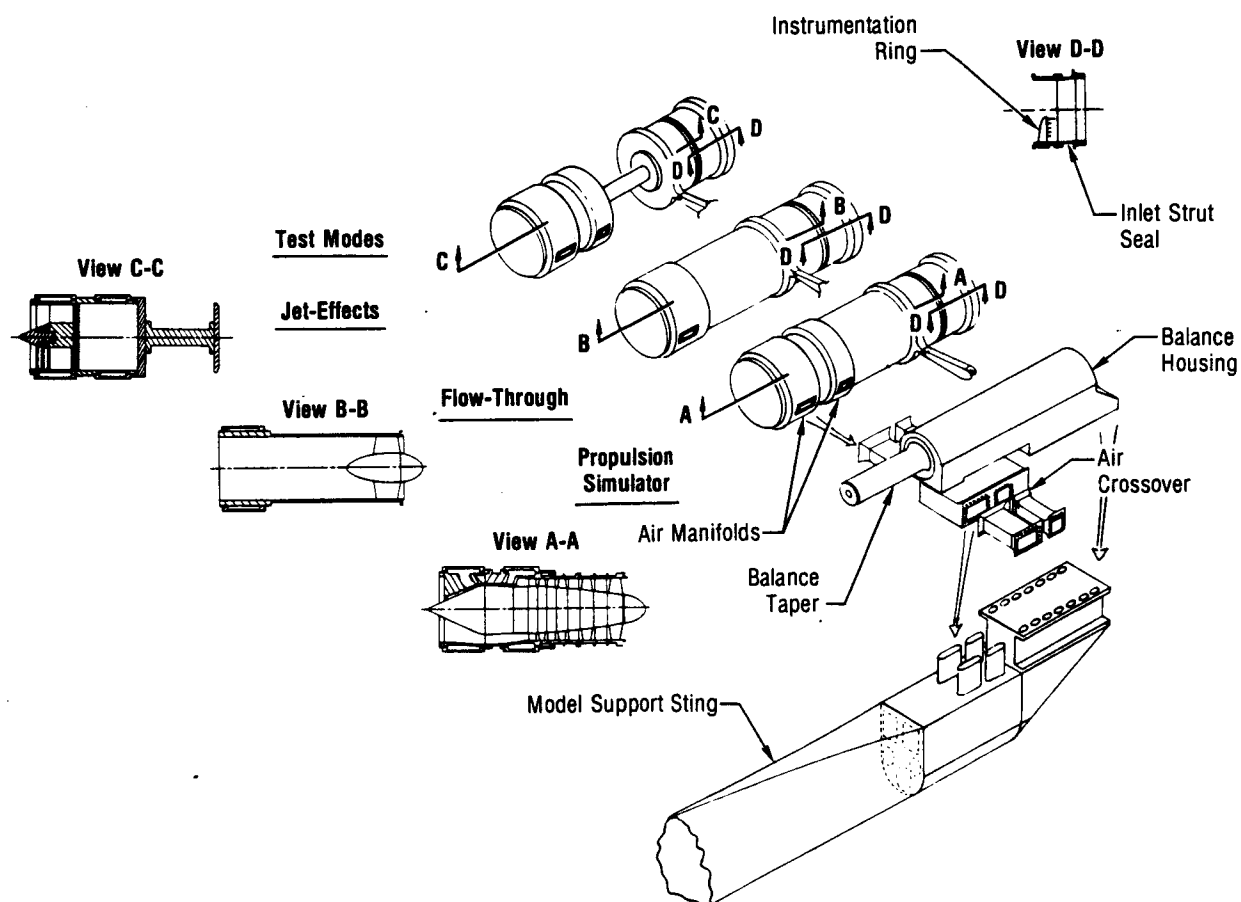
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Figure 2-9. Interchangeable Nacelle Core Hardware

In this section, the common hardware is further described, as well as the individual test modes.

2.1.1 <u>Common Model Support System and Metric Arrangement</u> -
The support system and metric arrangement were common between the
three test modes to eliminate test technique bias errors. The
model support system and core hardware provided the model-to-
facility interface for airflows and instrumentation and the struc-
tural support for both the metric and non-metric components of
the model. The support and core hardware consisted of the sting,
balance housing, air crossover, air manifolds, nozzle support,
front simulator mount, retainer, and transition duct. These
components are shown in Figure 2-10. The optional front simula-
tor mount was designed to remove torsional loads during the CMAPS
mode, but was flexible in the axial direction to allow limited
movement due to thermal growth. The front mount was not used in
this program in order to provide more space for instrumentation
lines. The nozzle support was used to react to axial loads and
nozzle vectoring loads.
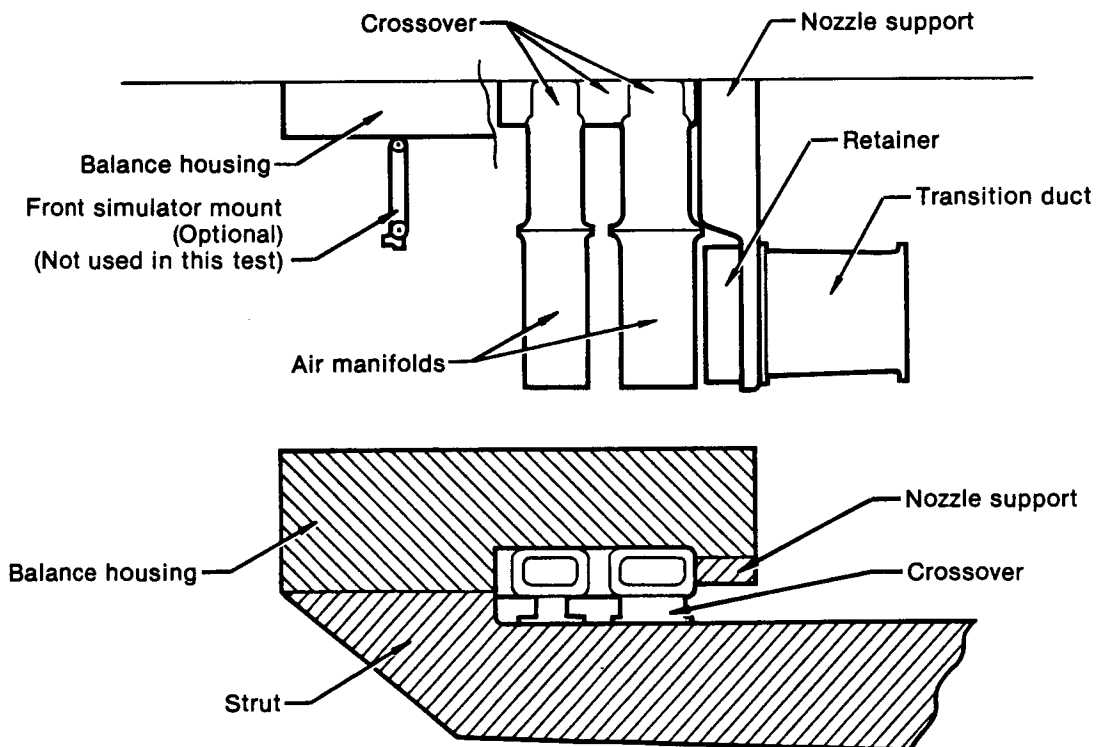
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Figure 2-10. Core Support Hardware

The retainer and transition duct served to deliver the air from the interchangeable nacelle components to the exhaust system. The retainer was firmly attached to the nacelle component and connected to the transition duct with a no-load seal. This seal isolated the interchangeable nacelle components from the exhaust system loads.

In each test mode, the model was supported by a single sting which extended from the center of the lower fuselage to the wind tunnel offset adapter. A schematic of the tunnel installation and support system is shown in Figure 2-11. This sting was selected as a compromise between a rear entry sting design and lower fuselage mounted "hockey stick" design. This selection is detailed in Reference 3.
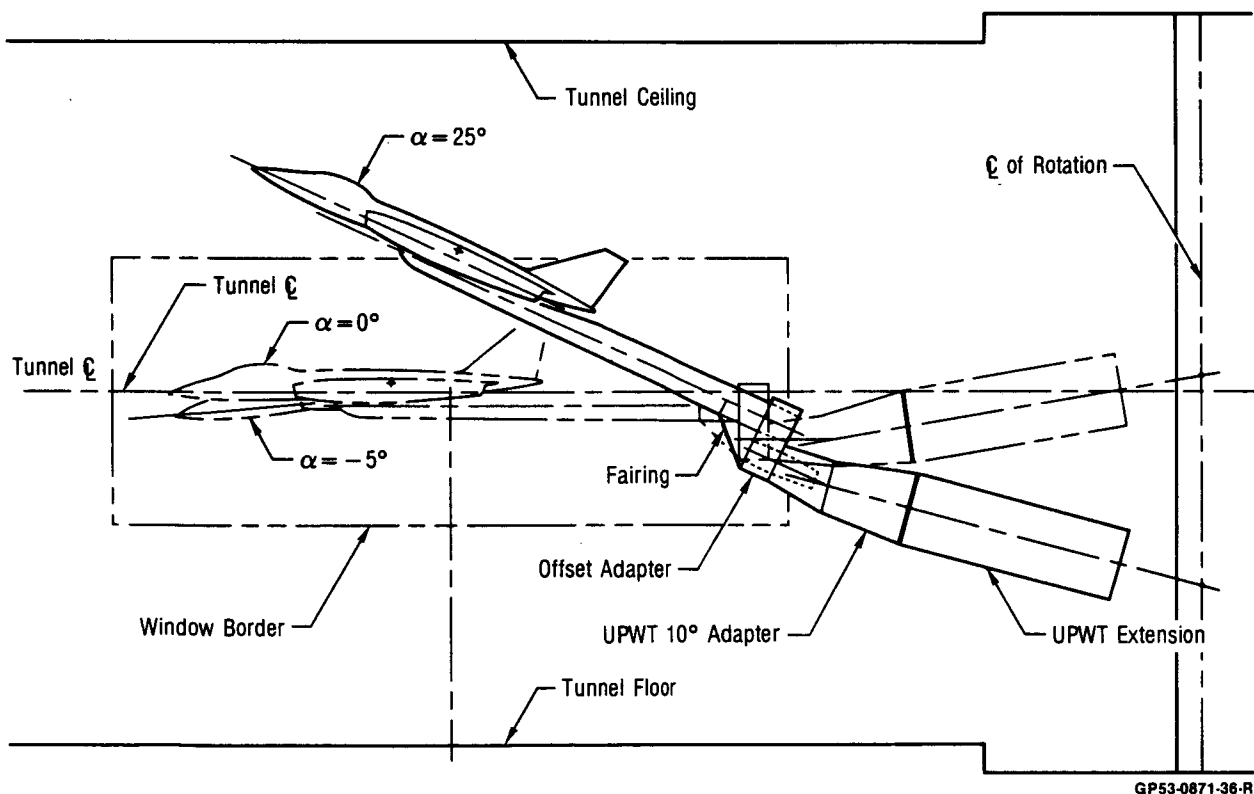
Figure 2-11. Model Installation in NASA-Ames 11 ft × 11 ft Unitary Plan Wind Tunnel

Four high pressure air passages, two for the CMAPS drive air and two for the bleed air, were contained in the sting along with a passage for model instrumentation lines. These passages, shown in Figure 2-12, were machined out of the solid 17-4PH stainless steel sting and sized to accommodate the airflow requirements of the propulsion simulators. At the offset adapter, these air lines, and the model instrumentation, connect with air supply lines and the instrumentation lines from the facility.
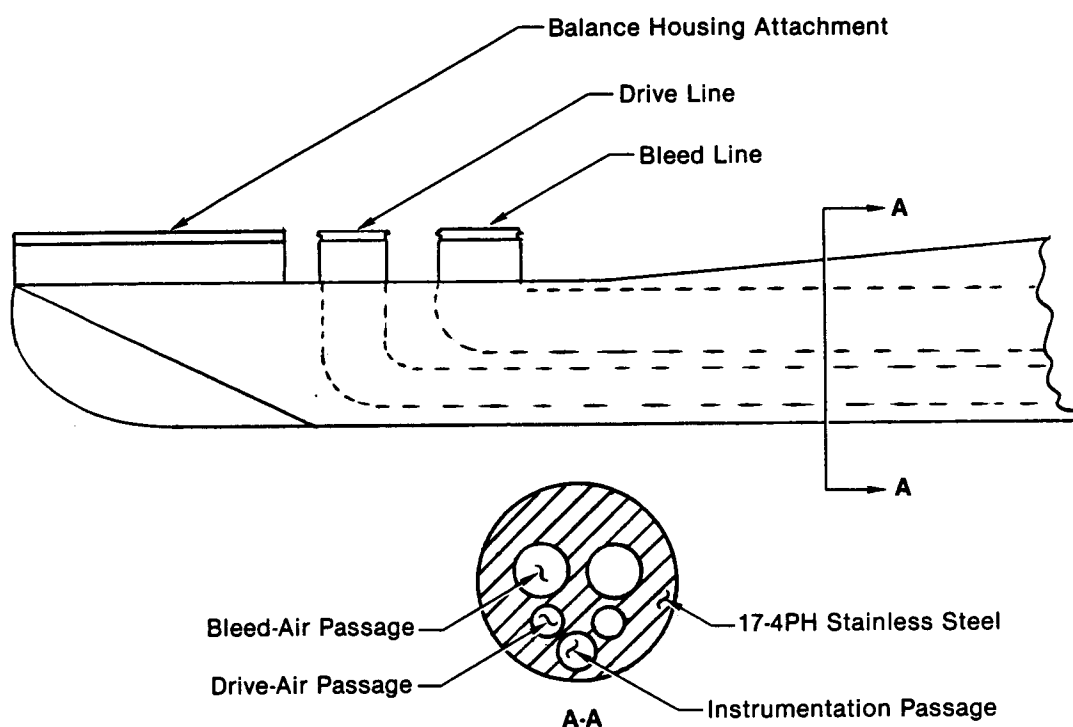
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Figure 2-12. Model Support Sting

Photographs taken during model assembly show the support system and core hardware. The assembled core hardware supporting the transition duct and "dummy" simulator is shown in Figure 2-13. A sideview of the same assembly with the balance installed is shown in Figure 2-14. The flow-through duct hardware supported by the bleed-air manifold is shown in Figure 2-15. The assembly of the core hardware onto the sting is shown in Figure 2-16.

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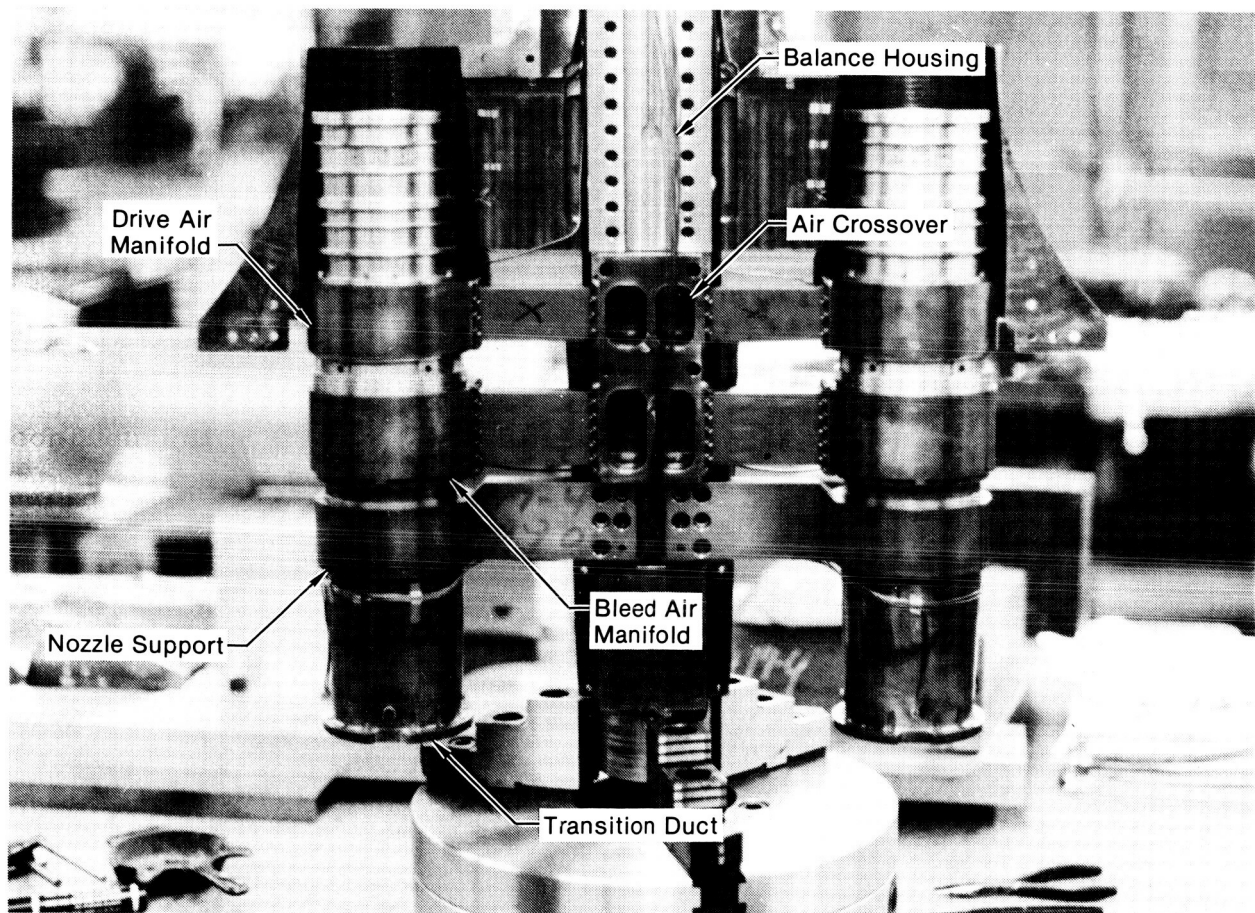
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Figure 2-13. Core Hardware
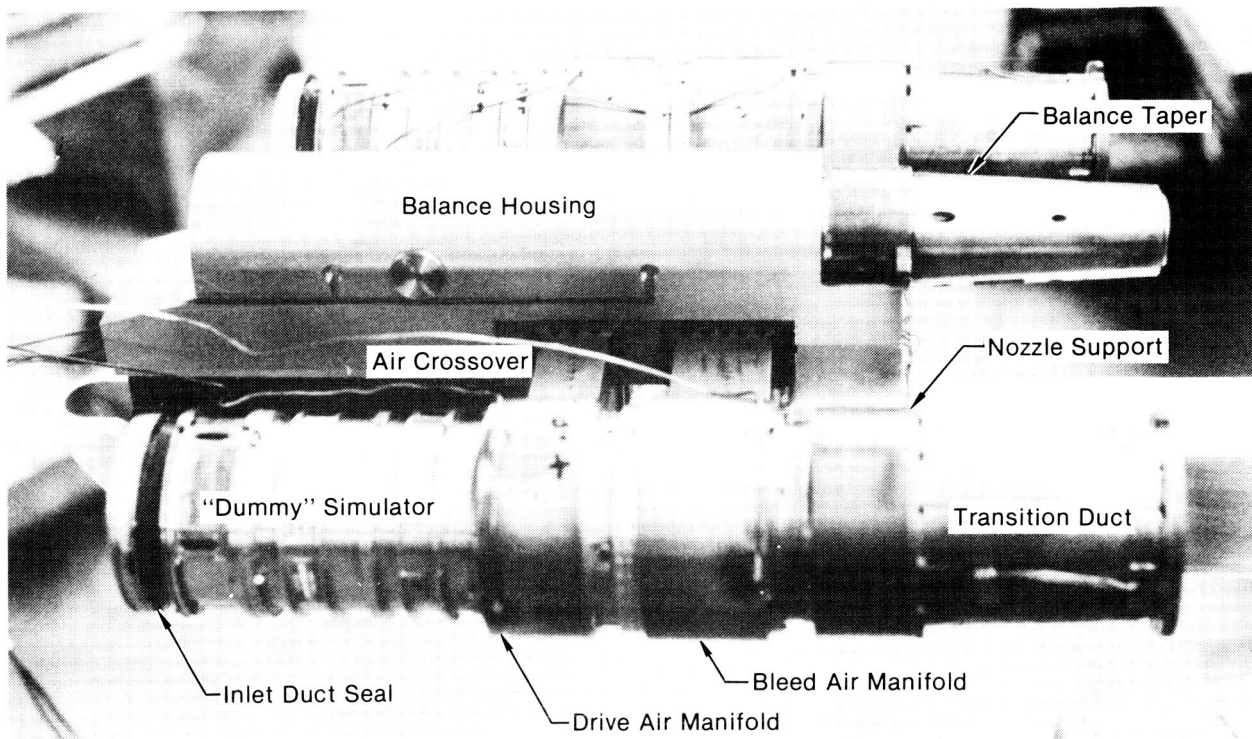
Figure 2-14. Core Hardware With Simulator

Labels: Balance Taper, Balance Housing, Air Crossover, Nozzle Support, "Dummy" Simulator, Transition Duct, Inlet Duct Seal, Drive Air Manifold, Bleed Air Manifold
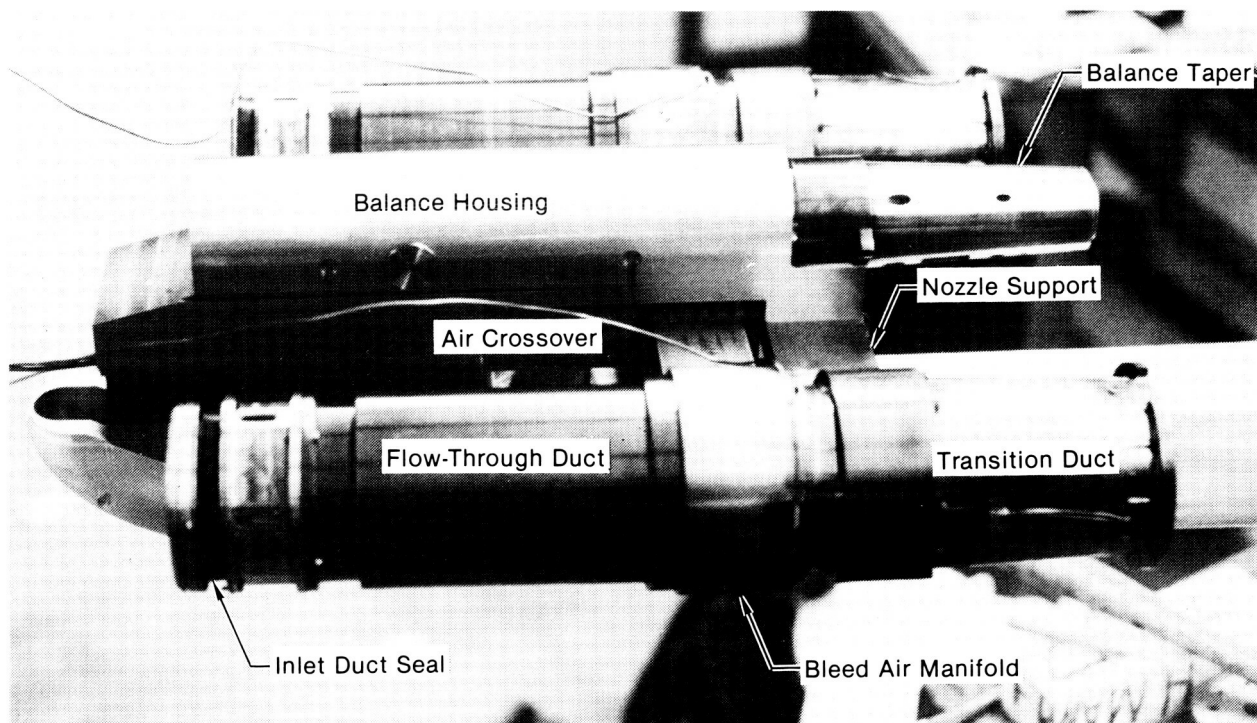
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Figure 2-15. Core Hardware With Flow-Through Duct

Labels: Balance Taper, Balance Housing, Air Crossover, Nozzle Support, Flow-Through Duct, Transition Duct, Inlet Duct Seal, Bleed Air Manifold
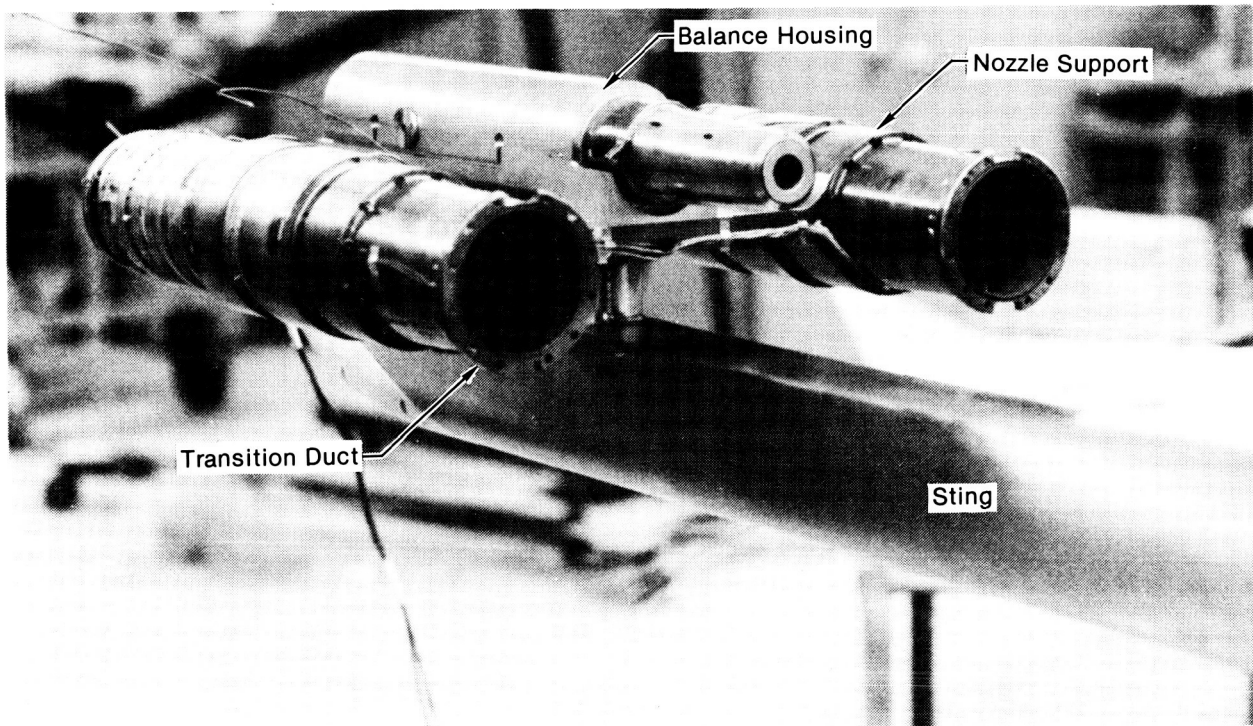
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Figure 2-16. Core Hardware on Sting

A common metric break seal arrangement was used for all three test modes. This arrangement consisted of three different seals: the nozzle metric break seal, the inlet duct seal, and the strut support seal, Figure 2-17.

The nozzle metric break seal was designed to prevent free movement of air into or out of the cavity. Therefore, a uniform cavity pressure was maintained and easily measured. The nozzle metric seal consisted of a stiff Teflon strip 1.067 cm (0.42 in.) long and 0.076 cm (0.030 in.) inches thick inserted into a slot in the nacelle shell 0.203 cm (0.080 in.) wide with four small coil springs in the shell applying a small axial force on the Teflon strip. This seal and spring arrangement allowed movement of the nozzle relative to the nacelle shell in the axial direction and in rotation while still keeping the seal flush against the nozzle.

17
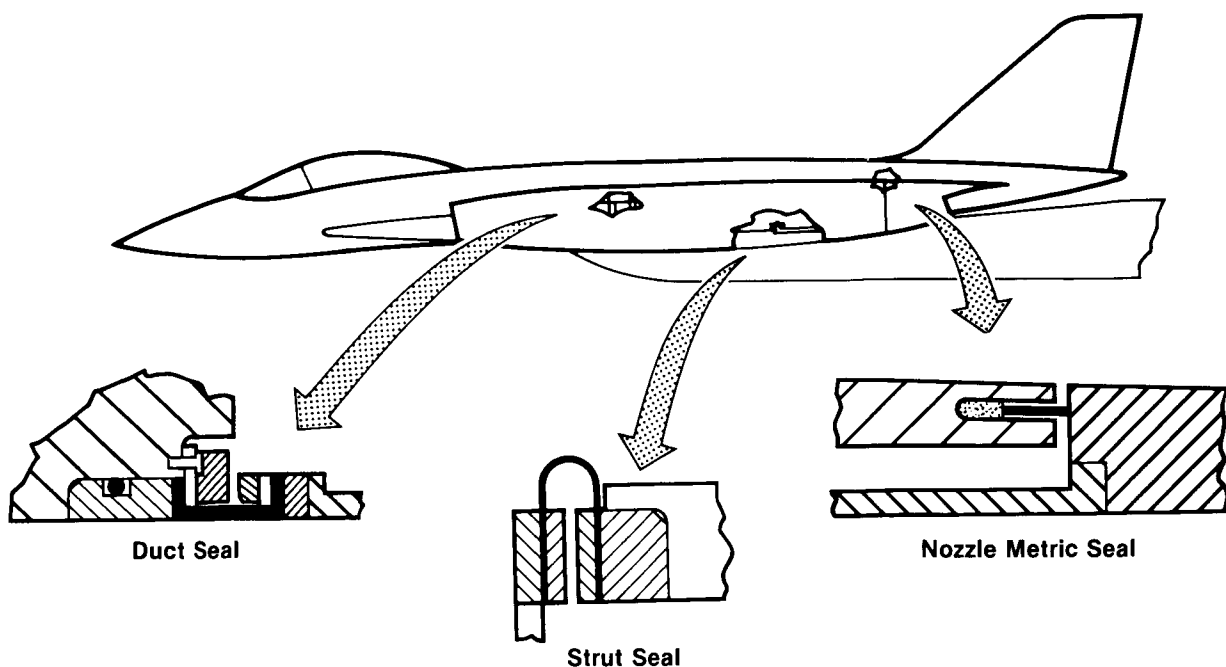
Figure 2-17. Metric Seal Arrangement

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The strut seal function was to prevent the external flow from causing non-uniform pressures in the model cavity. The strut seal was a thin race track shaped, pliable silicone rubber strip. This created an airtight, flexible seal around the bottom of the model between the non-metric strut and the metric model.

The inlet duct seal provided a leak-proof airflow transition between the metric inlet duct and the non-metric instrumentation ring. The instrumentation ring was the common component attached to the front of either the simulator, flow through duct, or jet-effects plenum hardware. The seal was a pliable, butyl rubber, flanged tube which allowed normal and axial direction movement while exerting predictable tares on the model.

2.1.2 CMAPS Mode - Propulsion simulators were installed in the engine nacelles for all the CMAPS mode testing. The engine face (Plane 2) total pressure rake and simulator compressor face can be seen behind the close-coupled inlet in Figure 2-18. The location of the CMAPS instrumentation planes is defined in Figure 2-19. A schematic of the nacelle hardware for the CMAPS mode is shown in Figure 2-20.

18
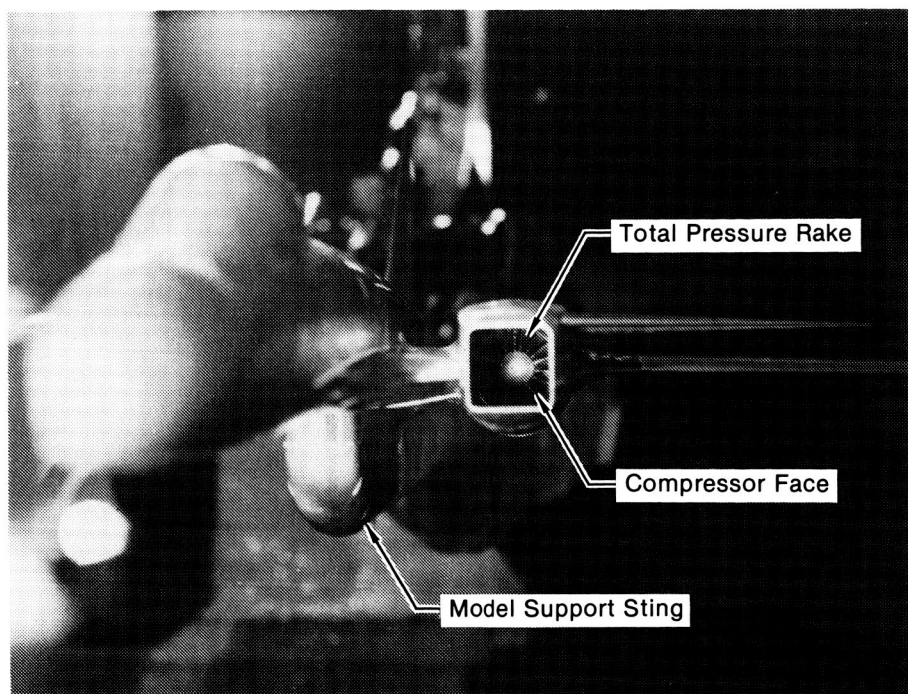
GP53-0871-35-R

Figure 2-18. Propulsion Simulator Installed in Left Hand Engine Nacelle
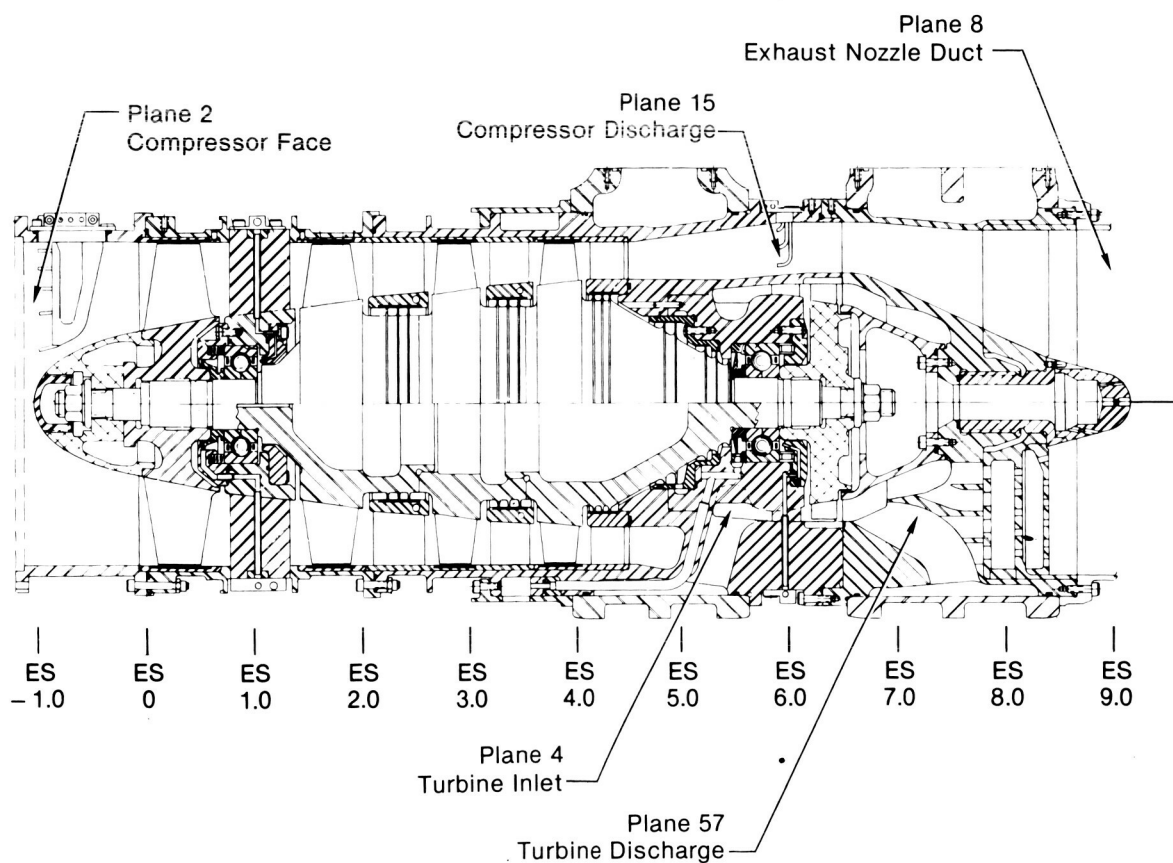
GP53-0871-16-R

Figure 2-19. CMAPS Instrumentation Planes

19

Common Drive Air
Line/Manifold

Common Bleed Air
Line/Manifold

Duct
Metric Break

Top View

Common Seal and
Instrumentation
Ring

CMAPS

FS 36.330

FS 45.080

Inlet Duct Seal

Sheer View

Drive Air Mainfold

Bleed Air Manifold

GP53-0871-57-R
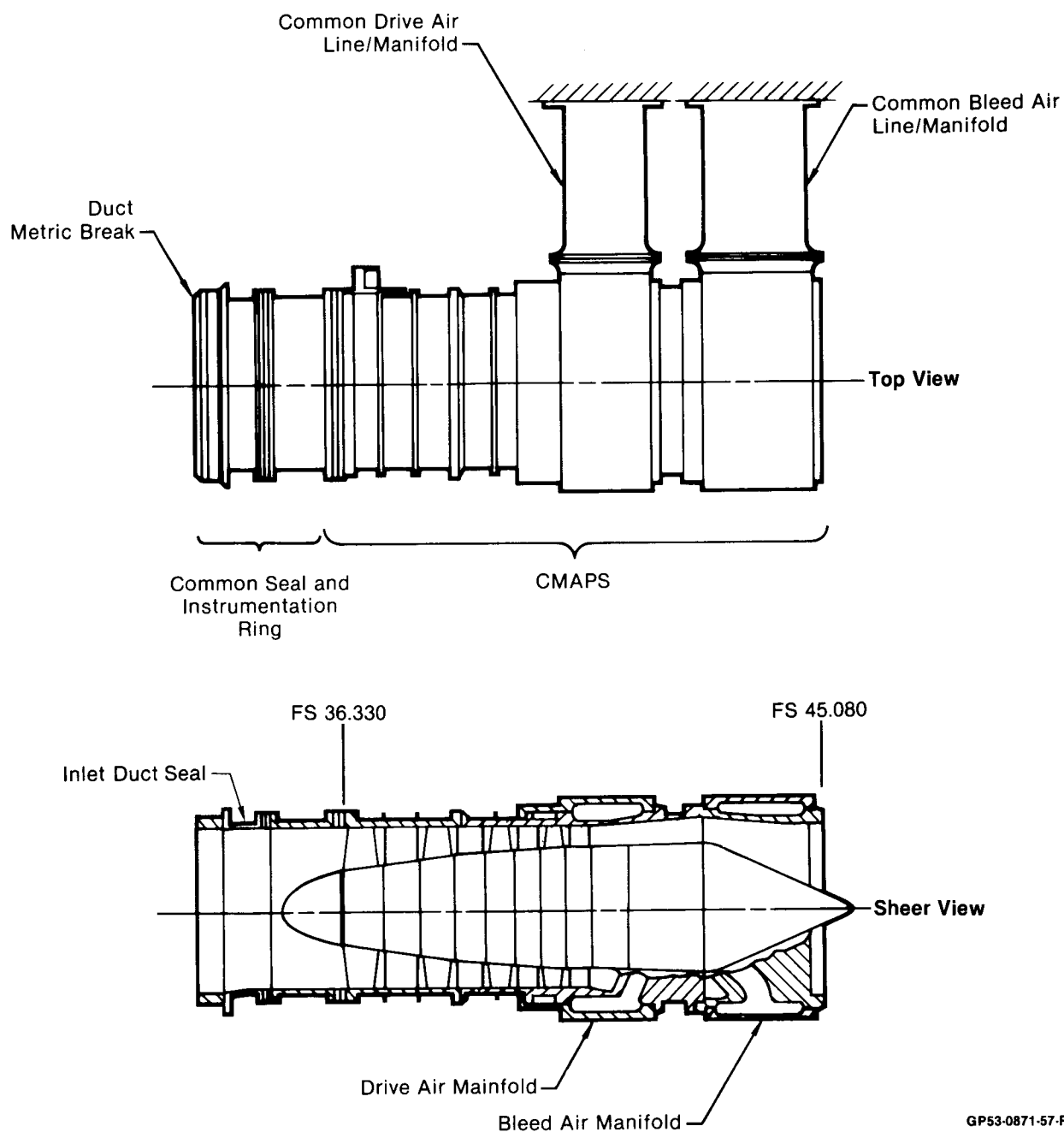
Figure 2-20. CMAPS Mode Nacelle Core Hardware

Independent control of the high pressure air through the
drive and bleed lines in the support sting allowed the simulator
to produce desired combinations of inlet and nozzle flow
conditions independently.   A schematic of the simulator flow path
is shown in Figure 2-21.

CMAPS Airflow Schematic

GP53-0871-15-R
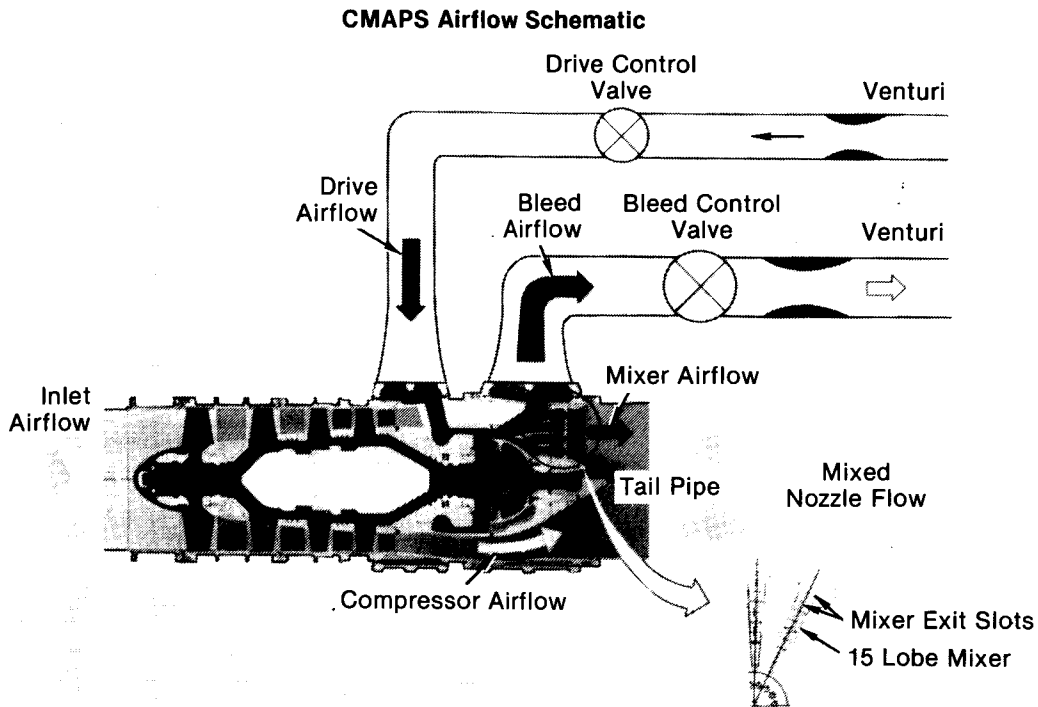
Figure 2-21. Simulator Internal Flow Paths

The Simulated Aircraft and the Nozzle Extension configura-
tions, as well as the Common Baseline configuration, were all
tested in the CMAPS mode. Data was acquired for the Simulated
Aircraft configuration in the form of angle-of-attack (AOA)
sweeps and engine pressure ratio (EPR) sweeps. The Nozzle Exten-
sion configuration data was taken for AOA sweeps at various
canard angles and mass flow ratios (MFRs). Only the largest exit
area chokes were used in the Nozzle Extension configuration for
the CMAPS mode. MFR was controlled solely by the simulators.
The Common Baseline configuration was tested in each test mode to
isolate tunnel induced effects due to separate tunnel entries. A
complete run matrix for the CMAPS mode is included in Appendix B.

2.1.3 <u>Jet-Effects Mode</u> - Plenum chambers replaced the simulators in the engine nacelles during the Jet-Effects mode testing. The nacelle hardware for the Jet-Effects mode is shown in Figure 2-22. The drive and bleed lines in the support sting were used to provide two independently controlled high pressure air sources to the plenum. The air was then mixed in the plenum and exhausted through the ALBEN's. This dual-flow plenum design was intended to duplicate the internal airflow paths and resultant pressure and temperature patterns encountered in the CMAPS mode. Although not required, the inlet duct seal was retained during the Jet-Effects mode in order to maintain a common seal arrangement between the three test modes.

Only the Common Baseline configuration was tested in this mode. Data was acquired with jet-on and jet-off AOA sweeps and nozzle pressure ratio (NPR) sweeps. A complete run matrix for the Jet-Effects mode is included in Appendix B.

2.1.4 <u>Flow-Through Mode</u> - Flow-through ducts were interchanged with the plenum chambers or simulators to build-up the Flow-Through mode. The non-metric duct units, Figure 2-23, were designed to model the propulsion simulators with respect to the internal inlet flow, particularly at the simulated engine face. Therefore, the Plane 2 total pressure rakes, inlet duct seals, and compressor face hubs were identical for Flow-Through and Simulator modes. Therefore, the Plane 2 total pressure rakes, inlet duct seals, and compressor face hubs were identical for Flow-Through and Simulator modes.

The Nozzle Extension configuration and the Nozzle Extension Baseline, as well as the Common Baseline, were tested in this mode. Inlet MFR was controlled in the Nozzle Extension configuration with four nozzle chokes sized as follows: 12.49 cm^2, 18.74 cm^2, 26.11 cm^2, and 34.25 cm^2. The internal flow path and exit choke geometry is shown in Figure 2-24. An ejector system was

Common Bleed Air Line/Crossover

Common Drive Air Line/Crossover

Duct Metric Break

Sheer View

Common Seal and Instrumentation Ring

Jet-Effects Air Supply Plenum

Inlet Duct Seal

FS 36.330

FS 45.080

Top View

Drive Air Manifold

Bleed Air Manifold
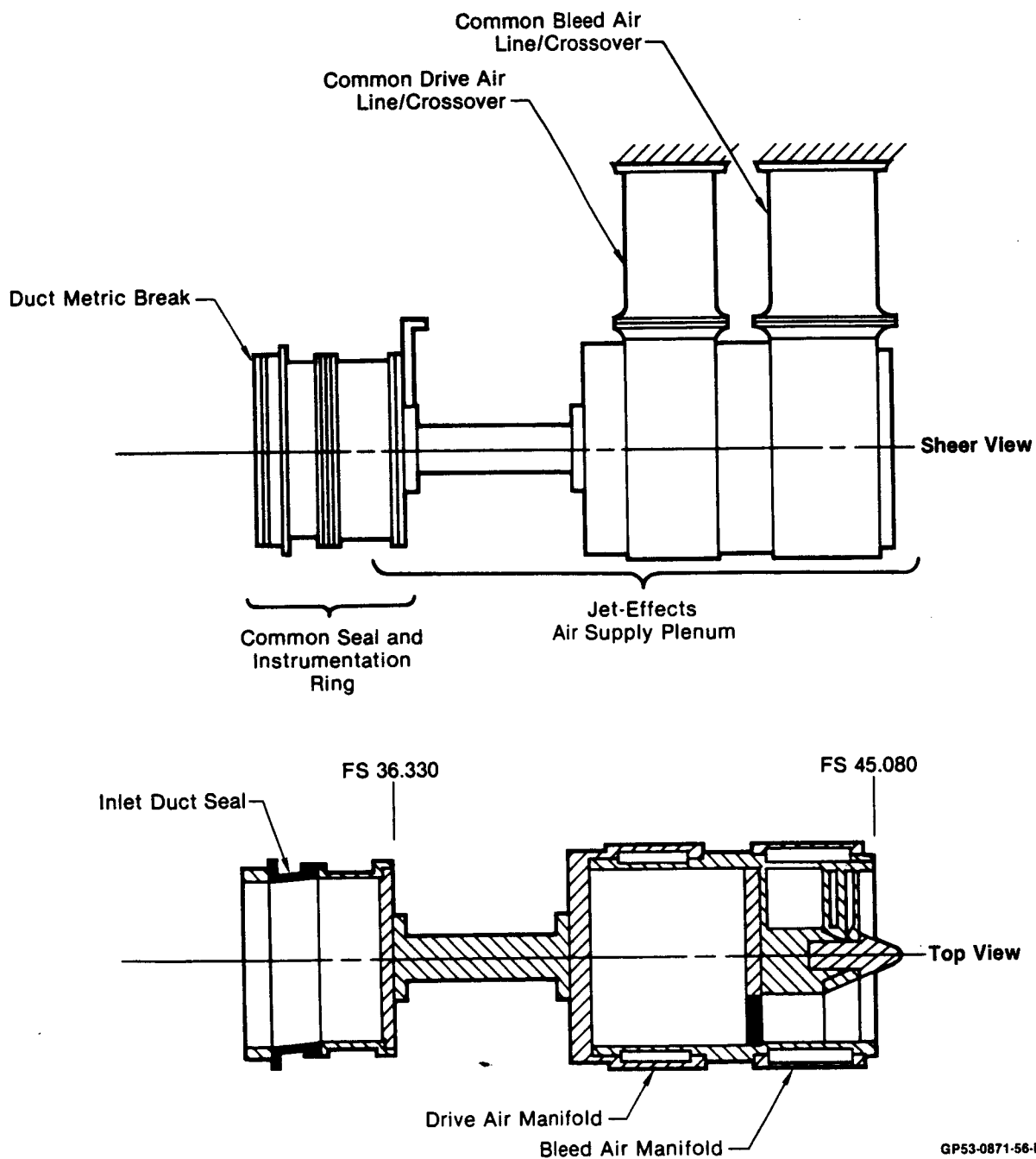
GP53-0871-56-R

Figure 2-22. Jet-Effects Mode Nacelle Core Hardware
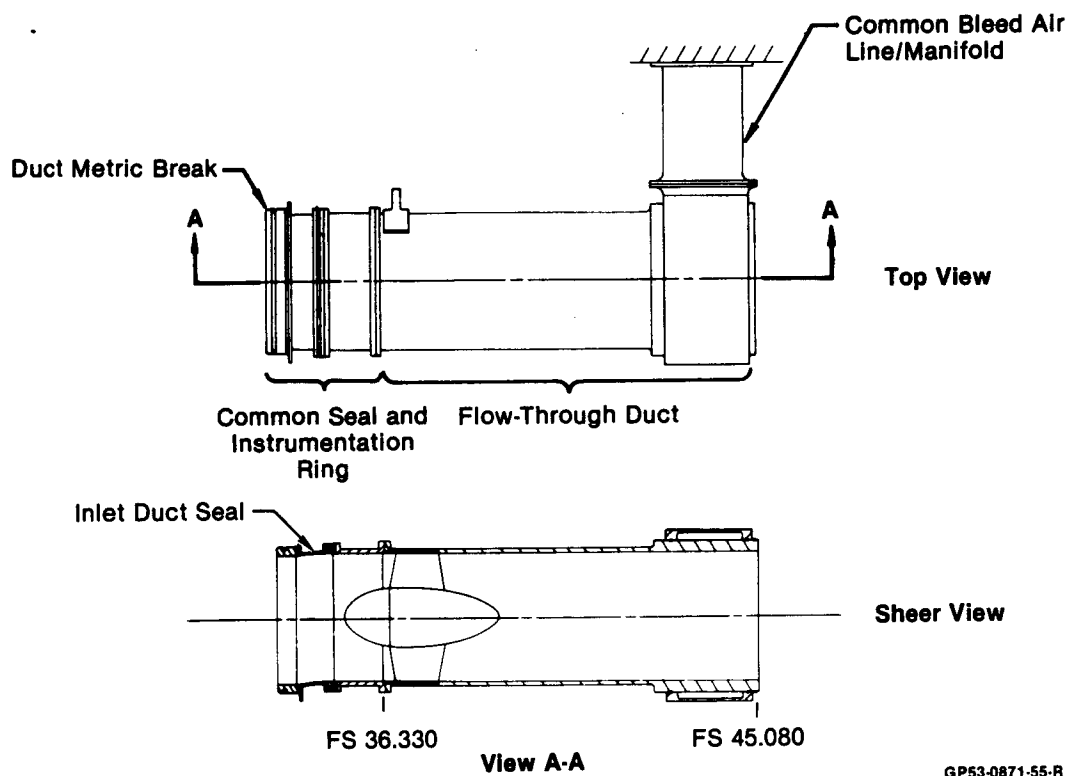
Figure 2-23. Flow-Through Mode Nacelle Core Hardware

Common Bleed Air Line/Manifold

Duct Metric Break

A

A

Top View

Common Seal and Instrumentation Ring

Flow-Through Duct

Inlet Duct Seal

Sheer View

FS 36.330

FS 45.080

View A-A

GP53-0871-55-R
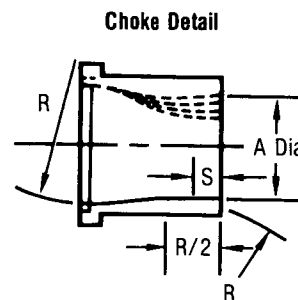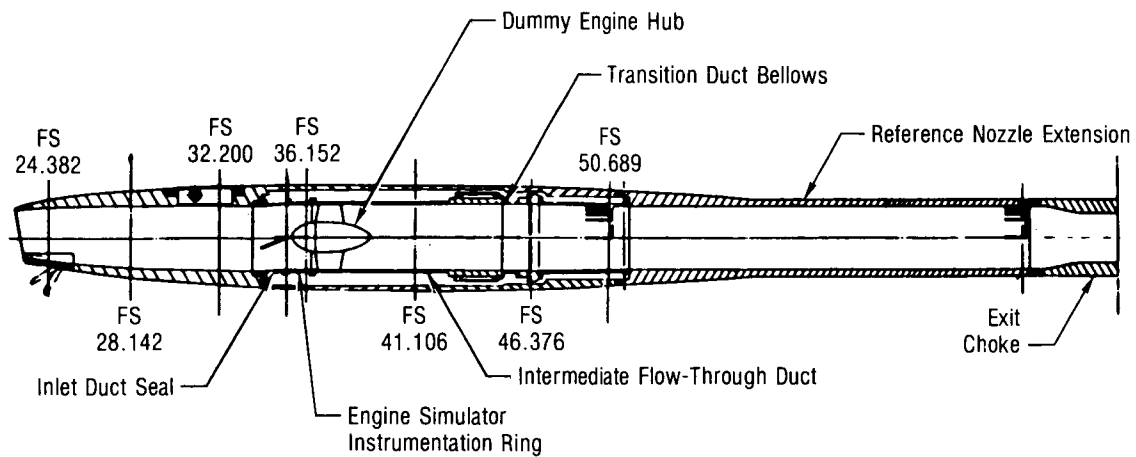
Convergent Choke Geometry

Drawing	A	A/2	A_{throat}	R	S
254-4452-5, -6	6.604 cm (2.600 in.)	3.302 cm (1.300 in.)	34.252 cm^2 (5.309 in.^{2})	12.637 cm (4.975 in.)	1.651 cm (0.650 in.)
254-4452-7, -8	5.766 cm (2.270 in.)	2.883 cm (1.135 in.)	26.110 cm^2 (4.047 in.^{2})	8.273 cm (3.257 in.)	1.440 cm (0.567 in.)
254-4452-9, -10	4.887 cm (1.924 in.)	2.443 cm (0.962 in.)	18.755 cm^2 (2.907 in.^{2})	6.711 cm (2.642 in.)	1.234 cm (0.486 in.)
254-4452-11, -12	3.988 cm (1.570 in.)	1.994 cm (0.785 in.)	12.490 cm^2 (1.936 in.^{2})	6.005 cm (2.364 in.)	0.996 cm (0.392 in.)

GP53-0871-34-R

Figure 2-24. Flow-Through Mode With Nozzle Extensions
Internal Flow Path and Exit Chokes

connected to the extension assemblies for Mach 0.4 and 0.6 testing, since the ram air was not sufficient to provide maximum airflow. The ejector installation is shown in Figure 2-25. The data was acquired with AOA sweeps at constant canard angles and inlet MFRs as shown in Appendix B.
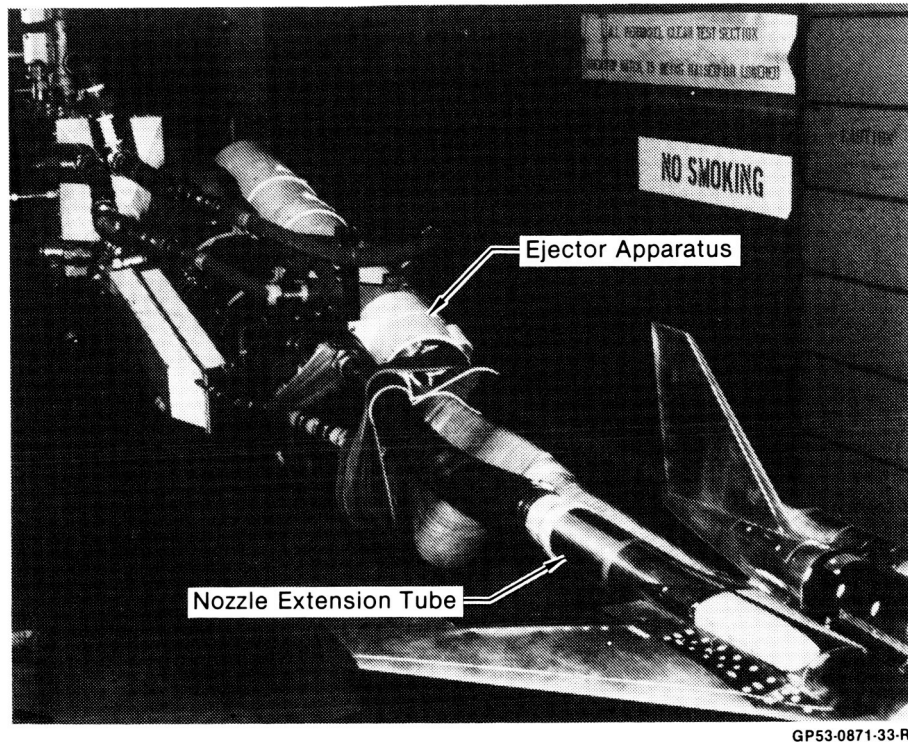
Figure 2-25. Ejector Apparatus Connected to Nozzle Extensions

2.2 <u>INLET/EXHAUST SYSTEMS</u> – Two inlet and two exhaust systems were tested on the twin podded engine nacelles.

    2.2.1 <u>Inlet Systems</u> – The inlet was tested in both a flowing and a faired configuration. The flowing inlet was a rectangular, normal shock design with 15° scarf angle and a rotating lower cowl lip. The flowing inlet system with 0° and 45° cowl lip rotations is shown in Figures 2-26 and 2-27 respectively. The cowl lip rotation is to reduce flow separation around the lip at high angle-of-attack conditions. However, only a limited amount of testing was performed on the 45° lip rotation configuration.

26
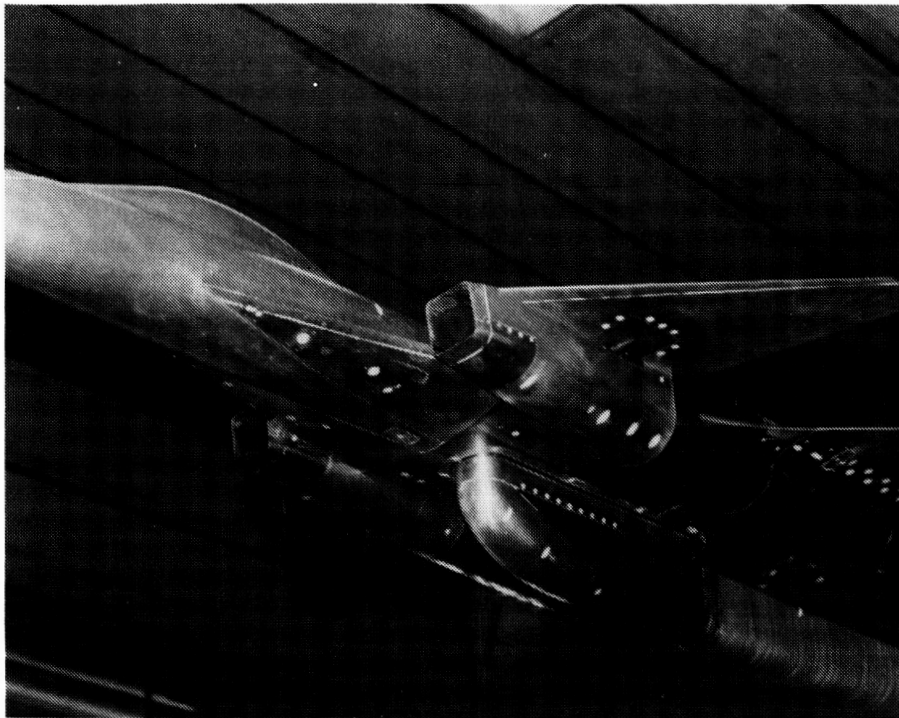
GP53-0871-26-R

Figure 2-26. Flowing Inlet System With 0° Cowl Lip Rotation
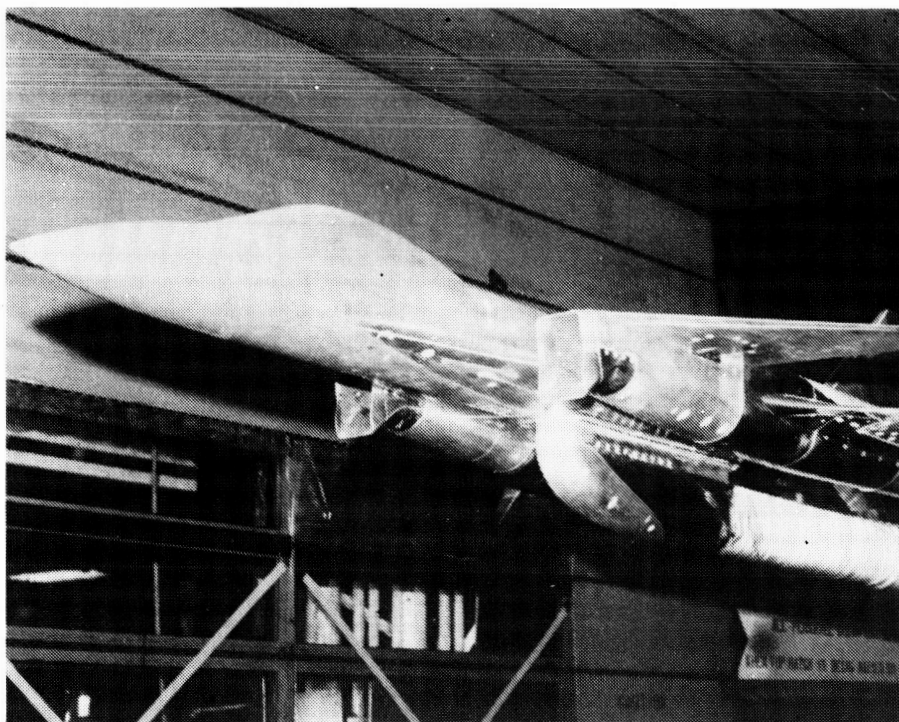
GP53-0666-60-R

Figure 2-27. Flowing Inlet System With 45° Cowl Lip Rotation

The faired inlet configuration was formed by installing pyramidal fairings to the flowing inlets with 0° lip rotation. The fairing shapes represented simple forward extensions of the local cowl moldlines. The model with the faired inlet system is shown in Figure 2-28.
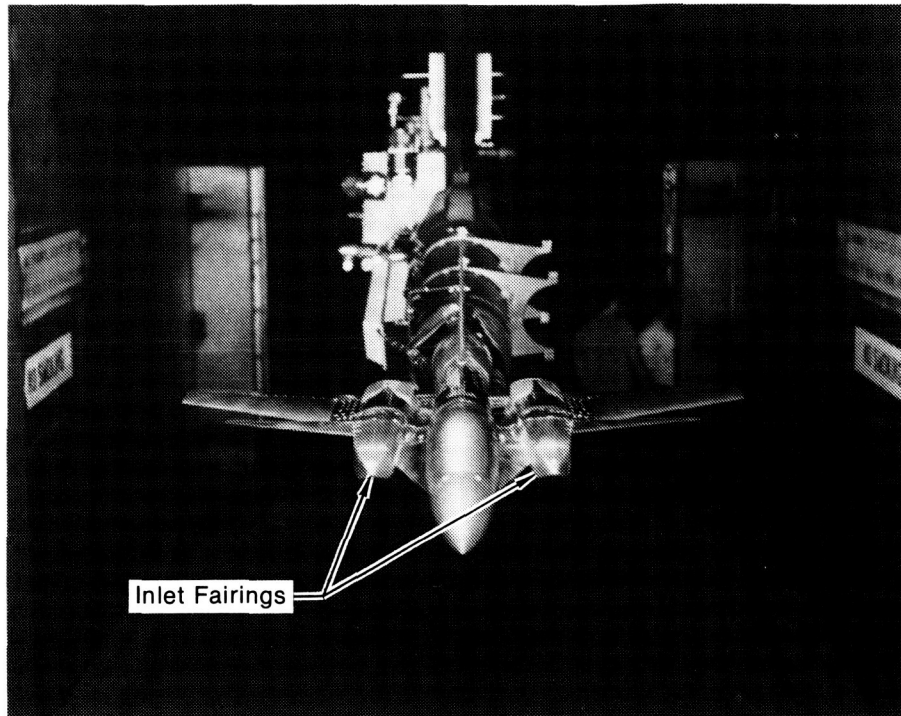
GP53-0871-32-R

Figure 2-28. Faired Inlet System on Test Vehicle

A second flowing inlet system was also fabricated for use on the alternate aircraft configuration (see Figure 1-2). However, it was never tested due to time constraints. This inlet was a circular design with a 13° reverse scarf angle, Figure 2-29.

The detailed design of these inlet systems is presented in Reference 7.
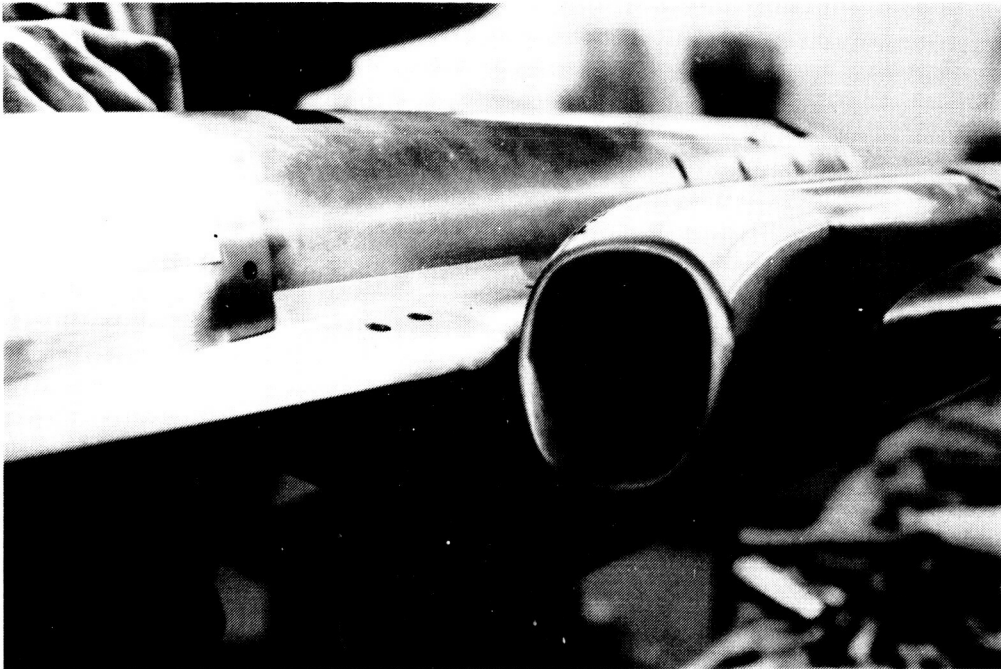
GP53-0871-14-R

Figure 2-29. Untested Inlet for Alternate Configuration

2.2.2 <u>Exhaust Systems</u> — The exhaust system was tested with both ALBENs and nozzle extension tubes. The ALBEN and nozzle extension systems were both non-metric to the internal aircraft balance. Both were pressure instrumented to obtain their external aerodynamic characteristics. The metric break and common station for the airframe/ exhaust system interface was at model station 50.689.

The ALBEN model was designed to simulate various power settings and thrust vectoring angles. The model configured with the ALBENs is shown in Figure 2-30. Two different power settings (dry and afterburning) were tested by interchanging the lower flap components, which change the throat and exit areas. Interchangeable upper flap components were used to configure the ALBENs for 0°, 20°, or 30° of thrust vectoring (vector angle measured from nominal horizontal reference plane, positive trailing edge down).

29
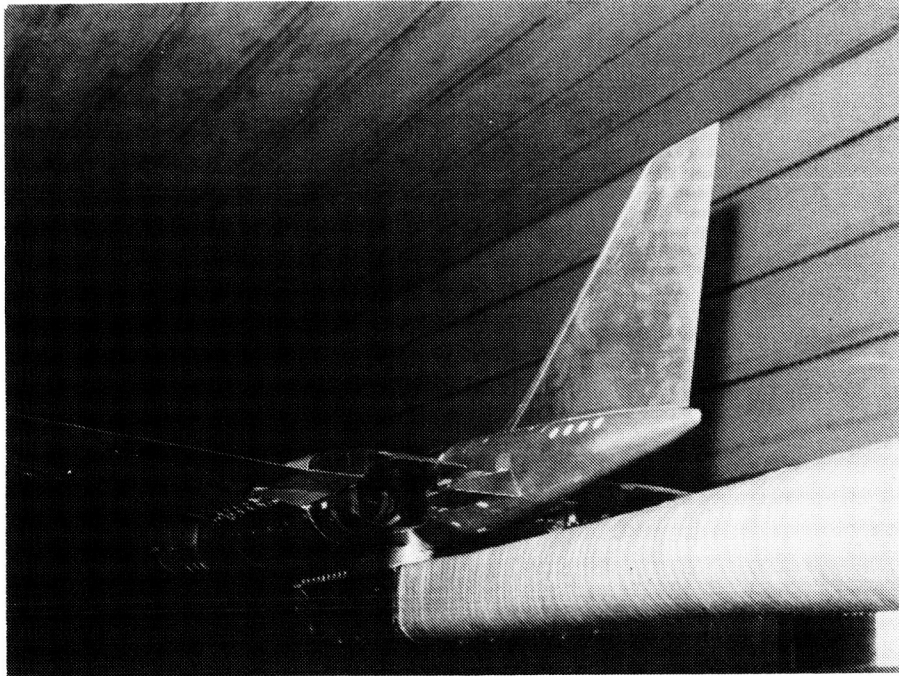
GP53-0871-31-R

Figure 2-30. Unvectored A/B ALBEN System on Test Vehicle

Nozzle extension assemblies replaced the ALBENs in order to isolate the flowing inlet effects from those associated with the exhaust plume. The extension tubes were sized such that the exhaust plume and base area effects would not be felt on the metric surfaces of the model. The nozzle extension installation is shown in Figure 2-31. Exit chokes were attached to the extension tubes to control inlet mass flow ratio (MFR). Four interchangeable chokes were used in the Flow-Through mode to cover the operating MFR range of the propulsion simulator.

2.3 TEST CONFIGURATIONS - The four test configurations (Figure 2-4) were used to identify the presence of flowfield coupling and measure the net effect. These configurations were tested in the three test modes as summarized in Figure 2-32.
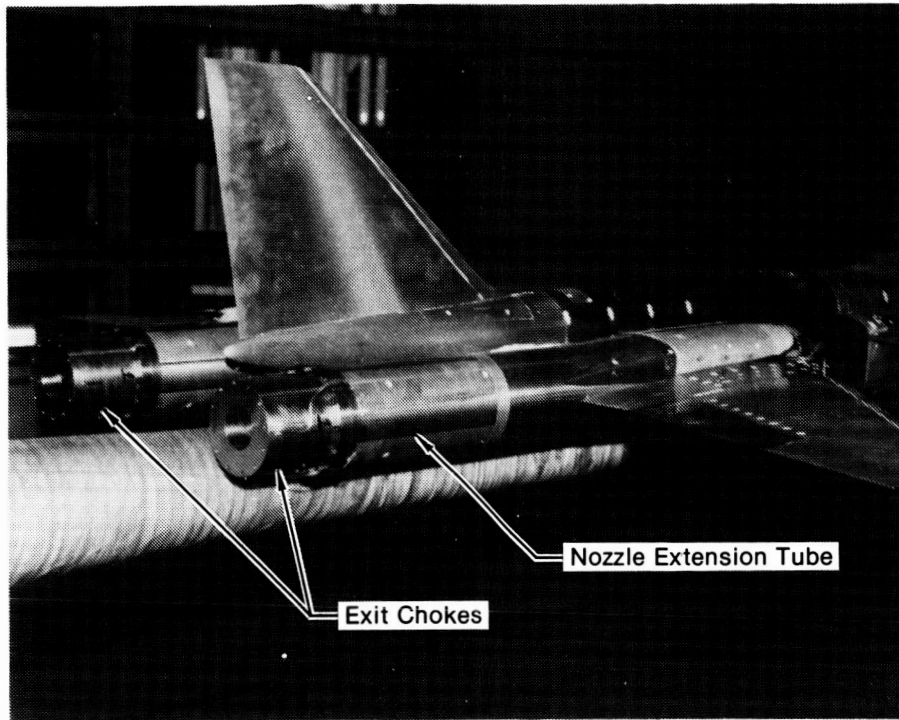
Figure 2-31. Nozzle Extension System on Test Vehicle

2.3.1 Common Baseline Configuration – The Common Baseline configuration is defined with faired inlets and the ALBEN exhaust system. This configuration, with unvectored A/B ALBENs in the jet-off condition, was tested in all three test modes to isolate any bias errors due to the separate tunnel entries.

The unvectored dry power ALBENs and vectored A/B ALBENs were also tested but only in the Jet-Effects mode. The A/B ALBEN system was tested at 0°, 20°, and 30° thrust vectoring. The 30° vectoring case was different from all other Jet-Effects configurations in that the wing flaps were also deflected 30°. This buildup, tested only at Mach 0.4, simulated the vehicle in a high-lift low-speed mode.

Configuration	Test Mode	Mach	MFR	NPR	α (deg)	δ_c (deg)
Common Baseline $\delta_N = 0°$ $\delta_F = 0°$ A/B ALBEN	F/T	0.4	N/A	1.0	$-1 \to 18$	$+5 \to -15$
		0.6				
		0.9				
		1.2			$-1 \to 10$	$+5 \to -10$
		1.4			$-1 \to 9$	
	J/E	0.4	N/A	$1.0 \to 4.0$	$-1 \to 18$	$+5 \to -15$
		0.6		$1.0 \to 6.0$		-5
		0.9		$1.0 \to 8.5$		-5
		1.2		$1.0 \to 11.0$	$-1 \to 6$	0
		1.4		$1.0 \to 14.0$	$-1 \to 6$	0
	CMAPS	0.4	N/A	1.0	$-1 \to 16$	$+5 \to -15$
		0.6				-5
		0.9				-5
		1.2			$-1 \to 6$	0
		1.4				0
Common Baseline $\delta_N = 20°$ $\delta_F = 0°$ A/B ALBEN	J/E	0.4	N/A	$1.0 \to 4.0$	$-1 \to 20$	-5
		0.6		$1.0 \to 6.0$	$-1 \to 22$	-5
		0.9		$1.0 \to 8.0$	$-1 \to 18$	$0 \to -15$
		1.2		$1.0 \to 12.0$	$-1 \to 7$	0
Common Baseline $\delta_N = 30°$ $\delta_F = 0$ A/B ALBEN	J/E	0.4	N/A	$1.0 \to 4.0$	$-1 \to 20$	$+5 \to -5$
Common Baseline $\delta_N = 0°$ $\delta_F = 0°$ Dry ALBEN	J/E	0.4	N/A	$1.0 \to 6.0$	$-1 \to 9$	$0, -5$
		0.6		$1.0 \to 6.0$		-5
		0.9		$1.0 \to 6.0$		$0, -5$
Nozzle Extension Baseline	F/T	0.4	N/A	1.0	$-1 \to 21$	-5
		0.6				
		0.9				$-5, -15$
		1.2			$-1 \to 6$	0
		1.4				
Nozzle Extension	F/T	0.4	$0.5 \to 1.2$	N/A	$-1 \to 22$	$+5 \to -15$
		0.6	$0.3 \to 0.9$			$0 \to -15$
		0.9	$0.3 \to 0.9$			$0 \to -15$
		1.2	$0.3 \to 0.9$		$-1 \to 6$	$0 \to -10$
		1.4	$0.3 \to 0.9$			$0 \to -10$
	CMAPS	0.4	$0.5 \to 1.2$	N/A	$-1 \to 17$	$+5 \to -15$
		0.6	$0.3 \to 0.9$			$0 \to -10$
		0.9	$0.3 \to 0.9$			$0 \to -10$
		1.2	$0.3 \to 0.9$		$-1 \to 7$	$0 \to -10$
		1.4	$0.3 \to 0.9$			$0 \to -5$
Simulated Aircraft	CMAPS	0.4	$0.7 \to 1.2$	$1.0 \to 3.5$	$0 \to 17$	$0 \to -15$
		0.6	$0.3 \to 0.9$	$1.0 \to 4.0$	$0 \to 17$	$0 \to -10$
		0.9	$0.4 \to 0.9$	$1.0 \to 5.0$	$0 \to 18$	$0 \to -10$
		1.2	$0.3 \to 0.8$	$1.0 \to 7.5$	$0 \to 6$	$0, -5$
		1.4	$0.3 \to 0.8$	$1.0 \to 9.5$	$0 \to 7$	$0, -5$

GP53-0871-29-R

Figure 2-32. Test Summary

2.3.2 Nozzle Extension Configuration - The Nozzle Extension configuration is defined as having the flowing inlet system and the nozzle extension exhaust system. The inlet was tested with both the 0° and 45° cowl lip rotations. Most of the 45° lip cases were tested with the wing flaps deflected 30° as shown in Figure 2-33.
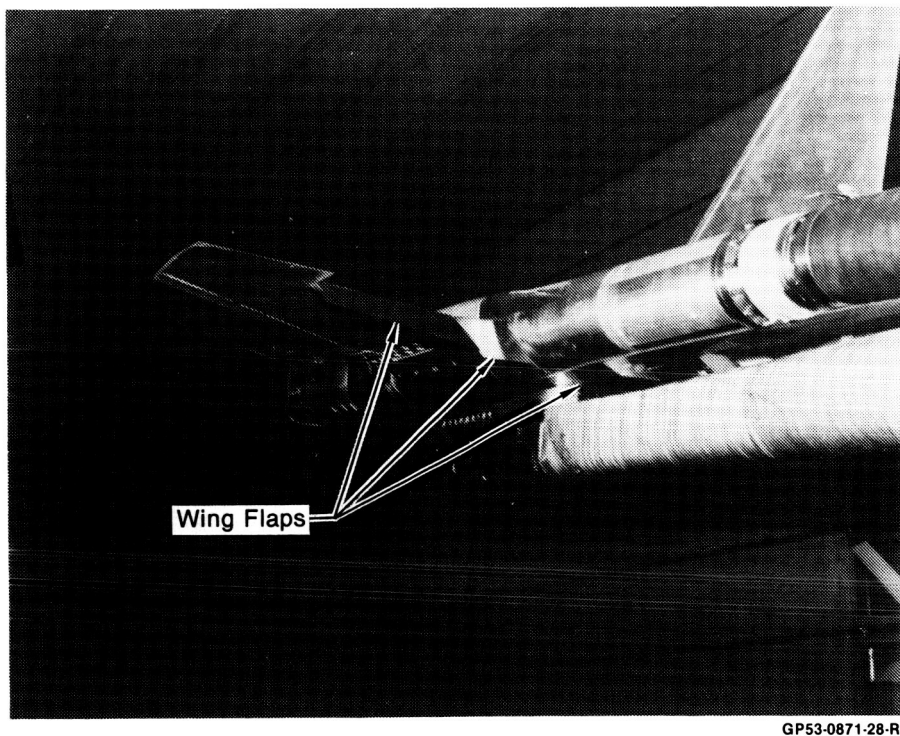
GP53-0871-28-R

Figure 2-33. Nozzle Extension Configuration With Wing Flaps Deflected 30°

This configuration models the flowing inlet effects on the airframe independent of the exhaust effects.

2.3.3 Nozzle Extension Baseline Configuration - The Nozzle Extension Baseline configuration is defined as having the faired inlet system and the nozzle extension exhaust system. In this configuration, only one canard angle was tested for each Mach number. The purpose of this build-up was to account for the nozzle extension effects on the airframe as compared to the ALBEN installation.

2.3.4   Simulated   Aircraft   Configuration   -   The   Simulated
Aircraft configuration is defined with flowing inlets and the
ALBEN exhaust system. This configuration was tested with only
the flowing inlets at 0° lip rotation and the ALBENs in the
afterburning (A/B) position with 0° thrust vectoring. This
configuration closely models an aircraft in flight, with jet
effects, inlet effects, and coupling effects measured simul-
taneously.

3. FACILITIES, INSTRUMENTATION AND DATA REDUCTION PROCEDURES

The nature of testing with propulsion simulators requires unique data acquisition and data reduction techniques. Even the Jet-Effects and Flow-Through modes were configured in slightly unconventional metric arrangements to reduce bias errors between test techniques (see Section 2.1). The facilities, instrumentation and data reduction used during this program are described in this section.

3.1 <u>FACILITY</u> - All testing was performed at NASA-Ames Research Center in the Eleven-by-Eleven-Foot Transonic Wind Tunnel (Moffett Field, California). This facility is a closed-return, variable density tunnel. It employs a fixed geometry, ventilated throat and a single-jack flexible nozzle. Airflow is produced by a three-stage/axial-flow compressor which is powered by four wound-rotor, variable-speed induction motors. The closed test section measures 11.0 feet high, 11.0 feet wide and 22.0 feet long. Flow speeds up to Mach 1.4 with corresponding Reynolds numbers of 9.4 million per foot are possible. The 11 ft. tunnel is one of three wind tunnels in the NASA-Ames Unitary Plan Wind Tunnel Complex. A schematic of the unitary complex and corresponding operating characteristics is shown in Figure 3-1.

3.2 <u>INSTRUMENTATION</u> - The model was instrumented to obtain the aerodynamic characteristics of the airframe and the nozzles. These characteristics were based on measurements of model forces and moments, pressures, temperatures, canard angle, and angle of attack. The airflow through the model was also calculated. A list of the instrumentation which is common to the three test modes is presented in Figure 3-2. Each propulsion simulator contained additional instrumentation to monitor its health and performance.
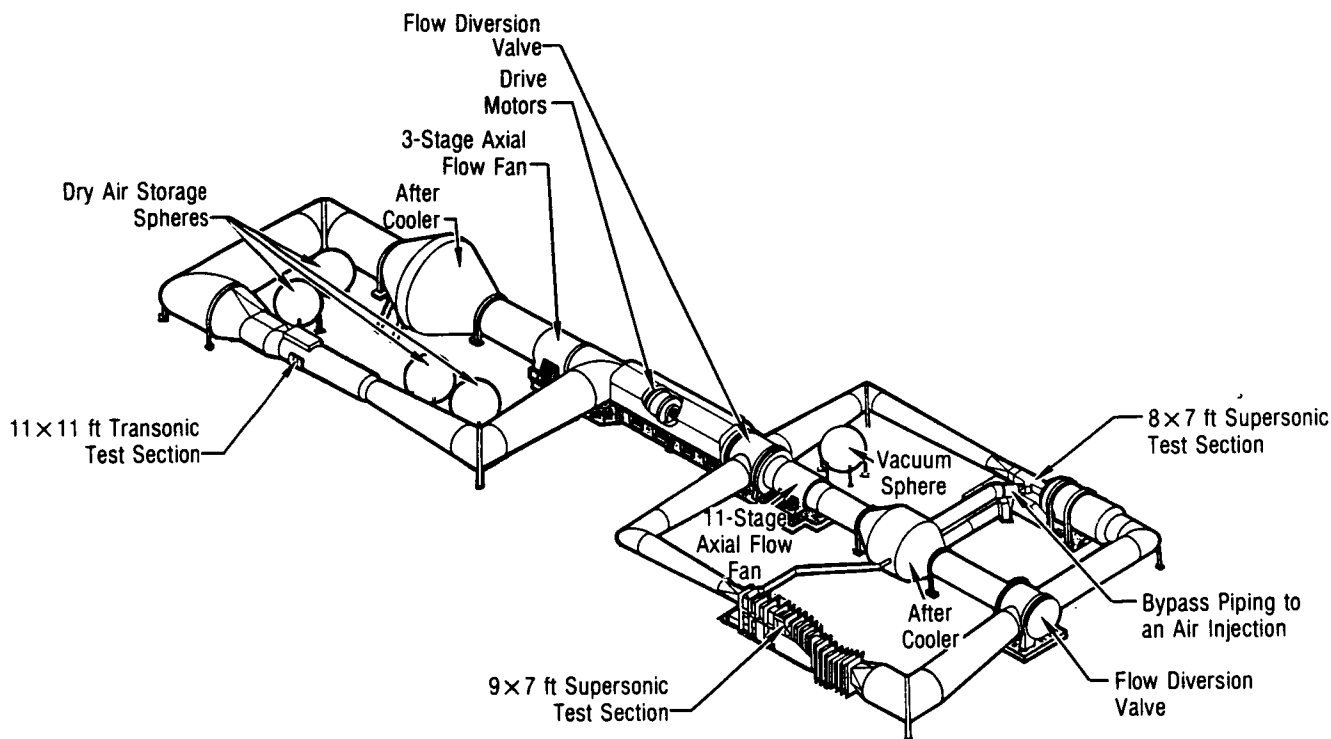
Major Components of the Unitary Plan Wind Tunnels

Unitary Test Sections	Height and Width (ft)	Speed Range (Mach)	Stagnation Pressure (atm)	Stagnation Temperature (°R)	Reynolds Number (ft)	Dynamic Pressure (lb/ft²)	Special Features
11 ft Transonic	11 × 11	0.70 – 1.4	0.5 – 2.25	580	$1.7 – 9.4 \times 10^6$	250 – 2,000	Slotted Test Section, 4 Watts
9 × 7 ft Supersonic	7 × 9	1.55 – 2.5	0.3 – 2.0	580	$1.5 – 6.5 \times 10^6$	200 – 1,450	
8 × 7 ft Supersonic	8 × 7	2.45 – 3.5	0.3 – 2.0	580	$1.0 – 5.0 \times 10^6$	200 – 1,000	

GP53-0871-23-R

Figure 3-1. NASA-Ames Unitary Plan Wind Tunnels

1) Forces and Moments		
Measurands	**Components**	**Balance**
Aircraft Balance Forces and Moments	6 (NF, AF, SF, PM, RM, YM)	Task Mark XXXII 2.5 in. Balance

2) Pressure Instrumentation			
	Number	**Range**	**Sensor**
Inner Wing Surface Static Pressures	14	± 15 psid	Internal Scanivalve
Outer Wing Surface Static Pressures	27	± 15 psid	Internal Scanivalve
Centerline Surface Static Pressures	10	± 15 psid	Internal Scanivalve
Nacelle Surface Static Pressures	45	± 15 psid	Internal Scanivalve
Nozzle Boattail Surface Static Pressures	50	± 15 psid	Internal Scanivalve
Internal Cavity Pressures	16	± 15 psid	Internal Scanivalve
Nacelle/Nozzle Seal Pressures	8	± 15 psid	Internal Scanivalve
Nozzle Total Pressures	18	± 15 psid	Internal Scanivalve
Nozzle Static Pressures	8	± 15 psid	Internal Scanivalve
Transition Duct Total Pressures	8	0 – 50 psia	

3) Temperature Instrumentation			
Balance Housing Temperature	10	60° – 200°F	Iron/Constantan Thermocouple
Transition Duct Total Temperature	4	60° – 400°F	Iron/Constantan Thermocouple

4) Miscellaneous			
Canard Deflection	2	− 10° to + 20°	Potentiometer
Angle-of-Attack	1	− 10° to + 40°	Internal Angle-of-Attack
Nozzle Mass Flow Rate	4	0 to 7 lb/sec	Venturi Flowmeter
Canard Root Bending Moment	1	± 1,500 in.-lb	Strain Gage

GP53-0909-3-R

Figure 3-2. Model Instrumentation Common to All Test Modes

Only the instrumentation required for the force and moment data acquisition is described in this section. The external pressure instrumentation is fully described in Volume I of this report (Reference 1).

3.2.1 <u>Force and Moment Balance and Thermal Control System</u> — The external aerodynamic loads were measured with a Task MK XXXII strain gage balance unit. The six component balance measured all forces and moments, except those on the ALBEN or nozzle extension assemblies. The aerodynamic loads are transmitted to the 6.350 cm (2.5 in.) diameter balance through the balance taper and taper adapter. The balance physical dimensions and orientation are shown in Figure 3-3. This non-standard balance installation with the taper loaded, resulted from the required locations of the drive and bleed air lines inside the model.
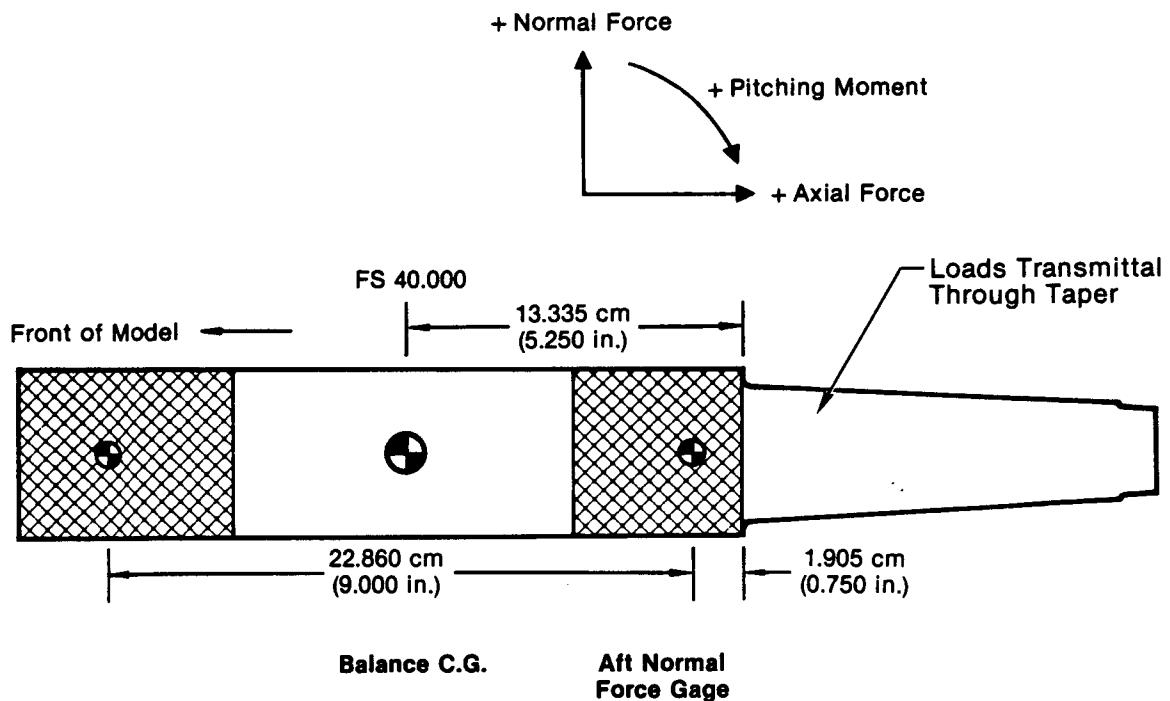
Figure 3-3. Model Balance

Since the force balance was subjected to a wide range of temperature environments in the three test modes, a balance thermal control system was provided to maintain the balance at a constant and uniform selected temperature. This was to prevent bias errors in the force balance output due to thermal gradients and levels.

The balance housing was divided into four heating zones, each with a heater blanket, controller and thermocouple feedback loop. The balance thermal control system configuration is shown in Figure 3-4. The thermal control system was designed to limit temperature gradients to about 1.5°C at an operating temperature of 71°C (160°F). The heater power density for steady state operation at selected tunnel conditions is given in Figure 3-5.
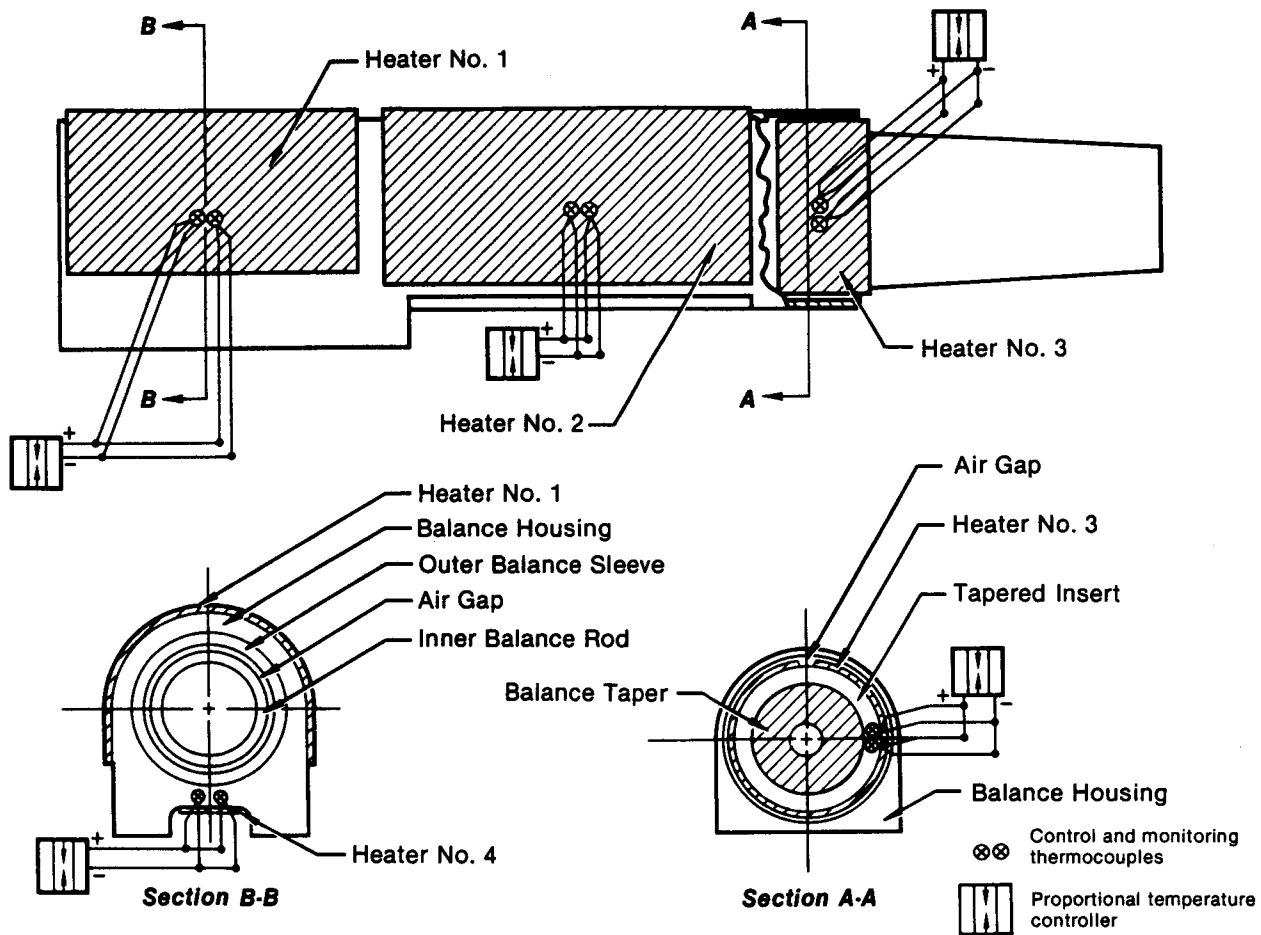
Figure 3-4. Balance Thermal Control System

Heater No. 1

Heater No. 2

Heater No. 3

B

A

Heater No. 1
Balance Housing
Outer Balance Sleeve
Air Gap
Inner Balance Rod

Heater No. 4

Section B-B

Air Gap

Heater No. 3

Tapered Insert

Balance Taper

Balance Housing

⊗⊗ Control and monitoring thermocouples

Proportional temperature controller

Section A-A

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Test Condition	Heater Number	Power Density (watts/cm^2)	Power (watts)
System Start-Up	1	0.178	35.35
• $T_{tunnel} = 26.67°C$	2	0.197	36.61
• 1 hr Required to Reach	3	0.716	37.34
Steady State	4	1.184	37.34
Flow-Through Mode[1]	1	0.037	7.45
• $M_{tunnel} = 1.4$	2	0.059	13.86
	3	0.454	34.05
	4	0.581	19.22
Simulator Mode[1]	1	0.031	6.09
• $M_{tunnel} = 1.4$	2	0.019	4.54
• $T_{drive} = 93.33°C$	3	0.426	31.92
• $T_{bleed} = 73.89°C$	4	0.532	17.56
Simulator Mode[1]	1	0.033	6.55
$M_{tunnel} = 1.4$	2	0.036	8.24
• $T_{drive} = 93.33°C$	3	0.414	31.08
• $T_{bleed} = 10°C$	4	0.544	17.97

Notes:
(1) Steady state operation
(2) The area of each heater is as follows

Heater no.	Area
1	198.09 cm^2 (30.7 in.^{2})
2	234.85 cm^2 (36.4 in.^{2})
3	74.85 cm^2 (11.6 in.^{2})
4	32.91 cm^2 (5.1 in.^{2})

GP53-0871-22-R

Figure 3-5. Heater Blanket Power Density

3.2.2 <u>Model Pressure Instrumentation</u> — A total of 226 pressures were measured on the model, including external static pressures, internal total pressures, seal and cavity pressures, and Scanivalve reference and calibrate pressures. The overall external surface tap layout is presented in Figure 3-6 and further detailed in Volume I of this report, Reference (5).

Legend:
  Open symbol — Upper surface
  Solid symbol — Lower surface
  1 flag — Upper and lower surface

60% chord — BL 25.649
40% chord
20% chord

BL 19.237
BL 16.031
BL 12.825

FS 10.00 FS 20.00 FS 30.00 FS 40.00 FS 50.00 FS 56.92
FS 64.81
BL 0.000

BL 3.200
BL 6.324

FS 22.45
FS 26.00
BL 12.825

FS 34.50
(End of inlet assembly)

FS 50.689
(Aft metric break)

Plan View

FS 51.235
FS 52.485
FS 53.735
FS 54.985
FS 56.235
FS 57.535
FS 58.735

WL 10.640

Nozzle Static
Pressure Taps

FS 55.204
FS 54.470
FS 53.735
FS 52.585
FS 51.240

BL 6.324

FS 27.50 FS 40.00
FS 25.375 FS 30.00 FS 50.00

FS 20.00
FS 32.25 FS 38.00 FS 45.19 FS 49.19
FS 64.81
FS 10.00 FS 24.00 FS 29.50 FS 43.19 FS 47.19 FS 56.92

Shear View

GP53-0871-52-R

Figure 3-6. Location of Model External Pressure Instrumentation

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Six Scanivalve modules were used to measure the model pressures. A four module, S-type Scanivalve was located in the forward fuselage and a two module, S-type Scanivalve was located in the aft fuselage as shown in Figure 3-7. Each Scanivalve was a synchronous, 48-port unit using a 15 psid transducer. The Scanivalves and transducers were provided by NASA-Ames.
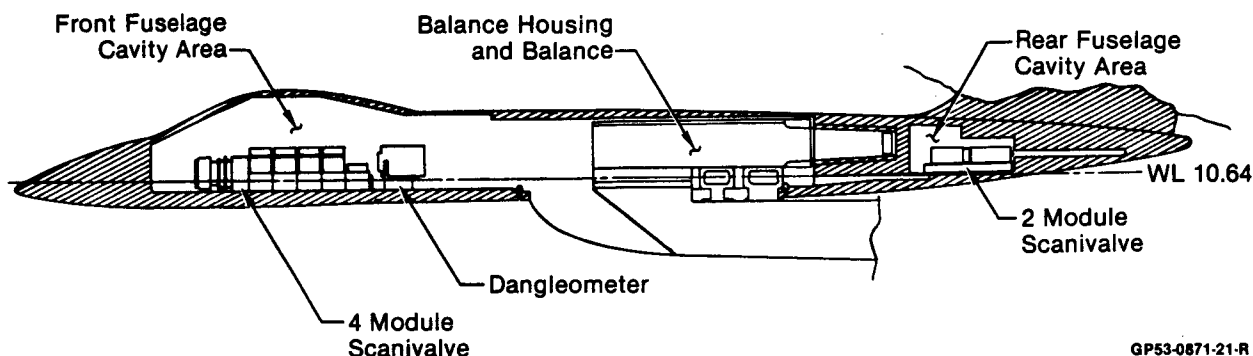
Figure 3-7. Fuselage Interior

Those pressure measurements requiring a larger transducer range than available at the Scanivalves were routed through the sting to a NASA supplied transducer housed in a temperature controlled pod.

3.2.2.1 ALBEN Surface Static Pressures - The non-metric ALBEN was instrumented with 49 surface taps. The tap layout across the ALBEN is shown in Figure 3-8. This large number of taps was used to perform a pressure-area integration from which lift, drag, and pitching moment on the nozzles were calculated.

3.2.2.2 Seal and Cavity Pressures - Eight static pressure orifices were distributed around the outside of the aft metric break seal on the left hand nacelle. The location of these orifices is shown in Figure 3-9. A pressure-area integration was performed with these measurements to calculate the axial force and pitching moment tares acting on this metric base area. The aircraft balance outputs were corrected for these tares.

42
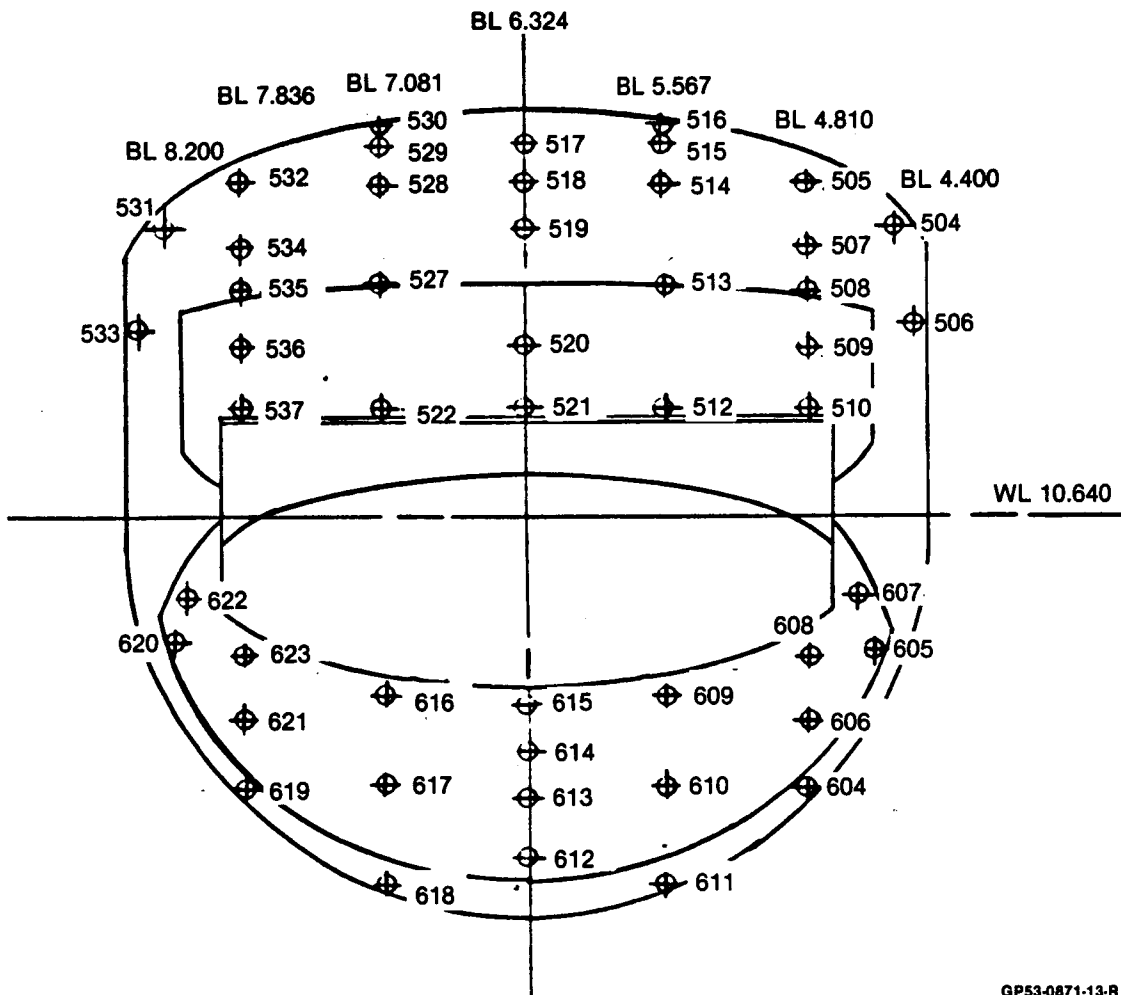
Figure 3-8. ALBEN External Pressure Instrumentation

GP53-0871-13-R

Sixteen pressure tubes were routed throughout the model to monitor cavity pressure. The location of these tubes is shown in Figure 3-10. These measurements were used to compute pressure-differential tares across the cavity seals, and were applied to the balance output as a correction term.

3.2.2.3 Model Total Pressure Instrumentation – Model total pressure instrumentation was used to measure airflow and to determine the engine pressure ratio and nozzle pressure ratio.
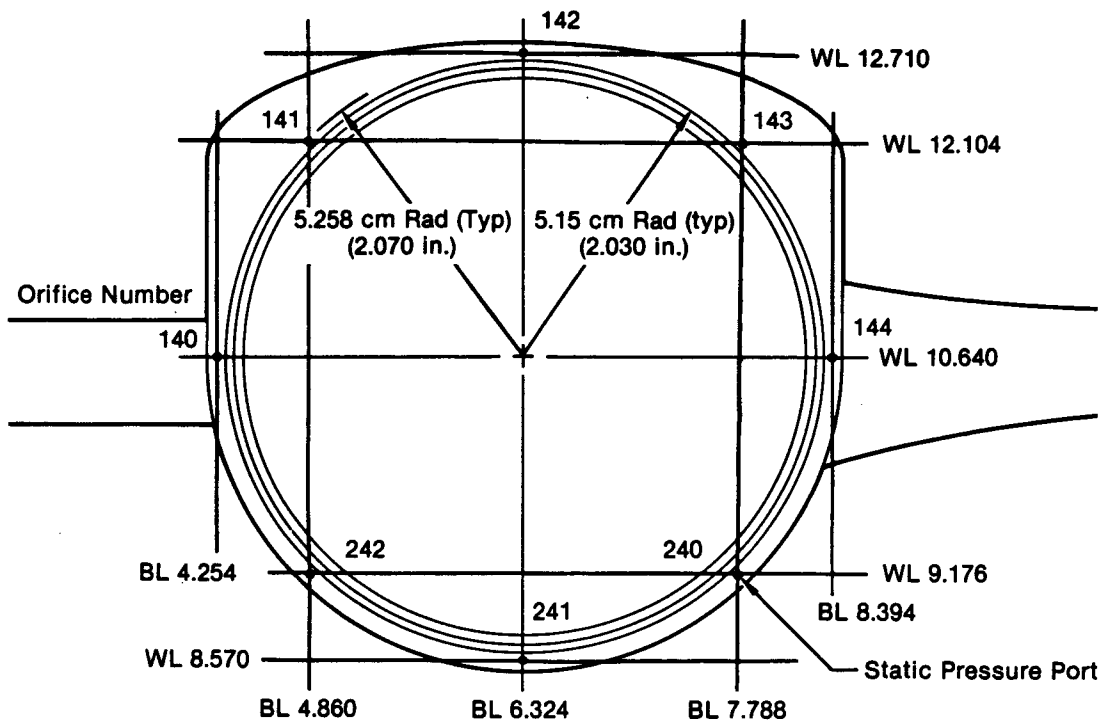
GP53-0871-43-R

Figure 3-9. Location of Aft Metric Break Seal Pressure Instrumentation FS 50.689

View looking up

Cavity pressure taps

1 - 4 Strut seal cavity
5 - 8 Engine face seal cavity
9 - 16 Metric break cavity
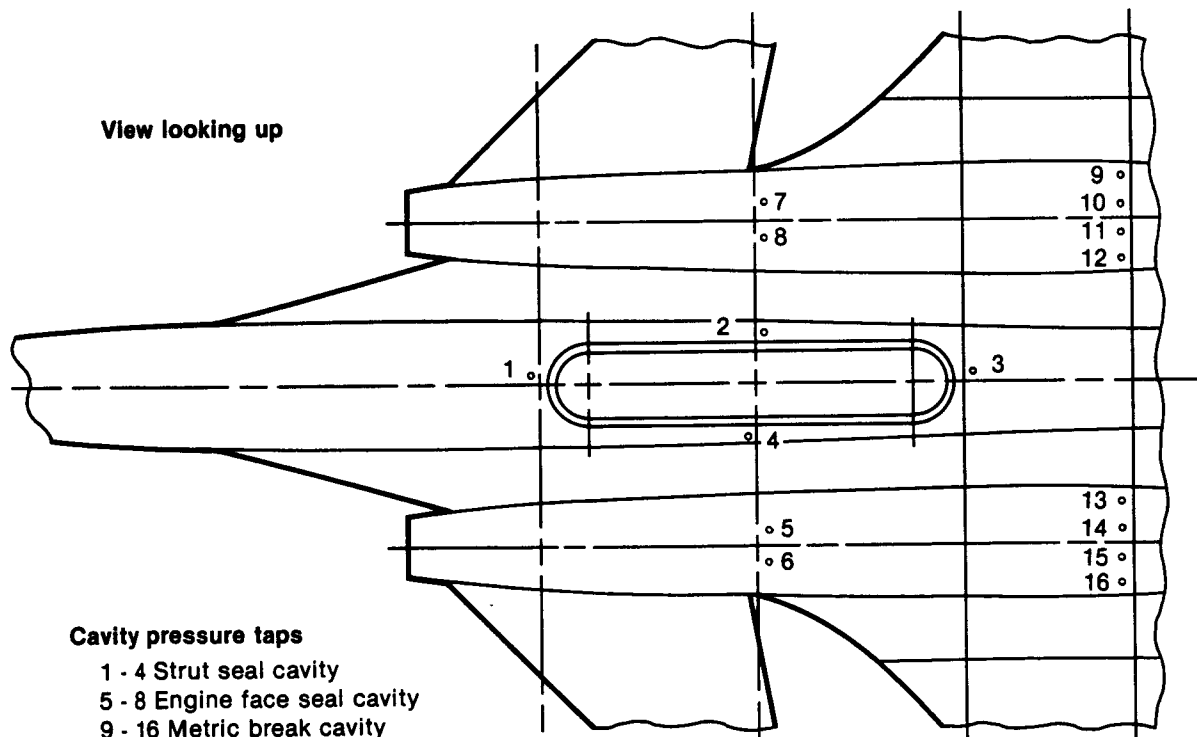
GP53-0871-44-R

Figure 3-10. Location of Cavity Pressure Instrumentation

Thirty-five (35) total pressure probes were located at the engine face, Plane 2. There were ten active probes on the left hand engine face rake and twenty-five (25) probes on the right hand engine face rake. A full description of the engine face pressure instrumentation is included in Volume I of this report.

The transition ducts each had four total pressure probes used in the calculation of nozzle pressure ratio and airflow. The total pressure probe locations are shown in Figure 3-11.

Each nozzle extension used during the Flow Through mode, also had a 9 probe total pressure rake. This rake was located at FS 68.000 as shown in Figure 3-11.
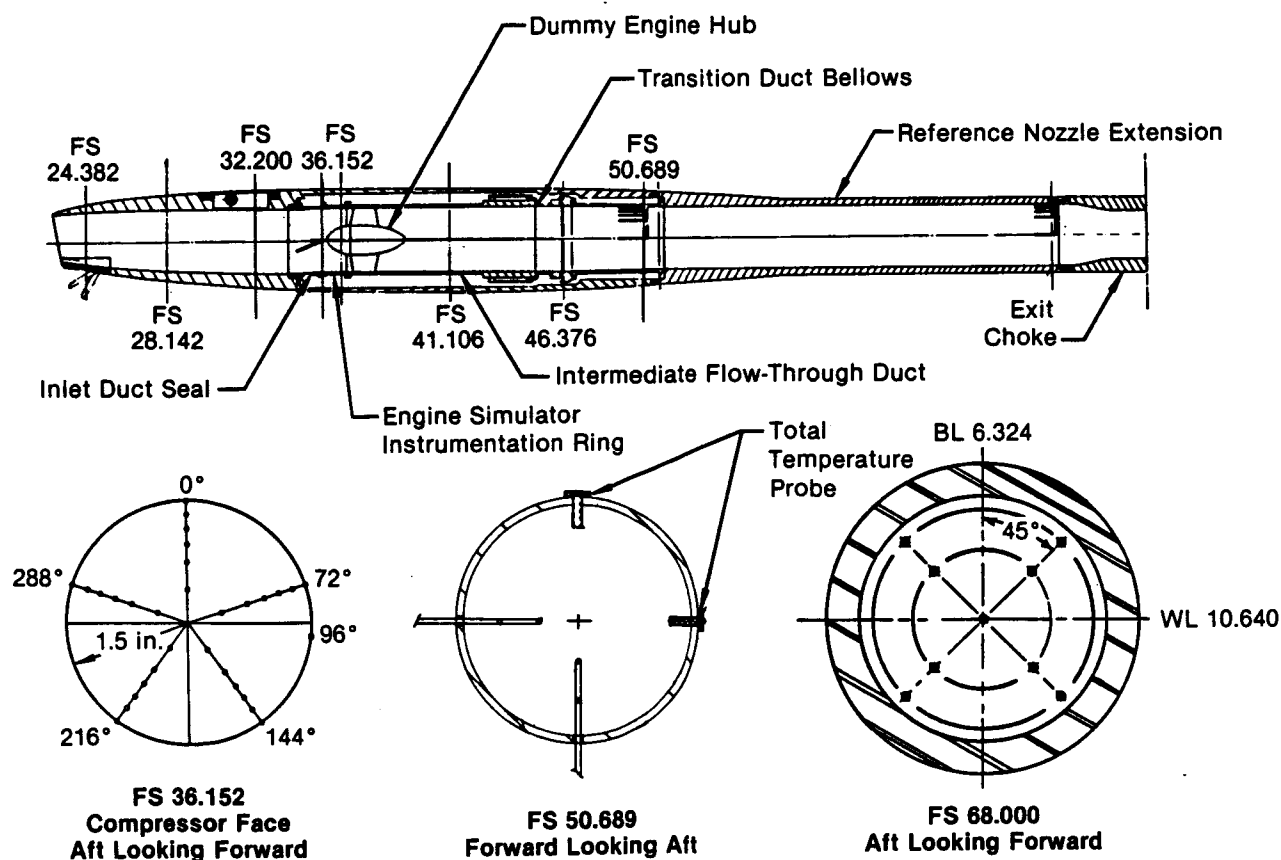
Figure 3-11. Location of Model Total Pressure Instrumentation

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3.2.2.4 <u>Internal Nozzle Static Pressures</u> - Each of the chokes and ALBEN models was instrumented with static pressure taps. The choke nozzles had four throat static pressure taps utilized in determining nozzle airflow. The pressure tap locations are shown in Figure 3-12. The ALBEN had three static pressure taps located on the expansion ramp as shown in Figure 3-6.

3.2.3 <u>Model Temperature Instrumentation</u> - Model temperature instrumentation was used for control of balance housing temperature and to measure nozzle duct total temperature.

The model balance housing was instrumented with eight iron/constantan thermocouples. Four of the thermocouples connected directly to the heater blanket controllers. The remaining four thermocouples measured the balance housing temperature at each heating zone for recording in the data system. Two additional thermocouples were attached directly to the balance, one at the taper base and one at the electrical connector housing. The location of thermocouples on the balance housing is shown in Figure 3-4.

The transition duct assembly had two iron/constantan thermocouples in each nacelle used in the calculation of duct airflow. The location of these thermocouples is shown in Figure 3-11.

3.2.4 <u>Miscellaneous Instrumentation</u> - Instrumentation was installed on the model to measure angle-of-attack, canard deflection angle and canard root bending moment. The instrumentation for these measurements is listed in Figure 3-2.
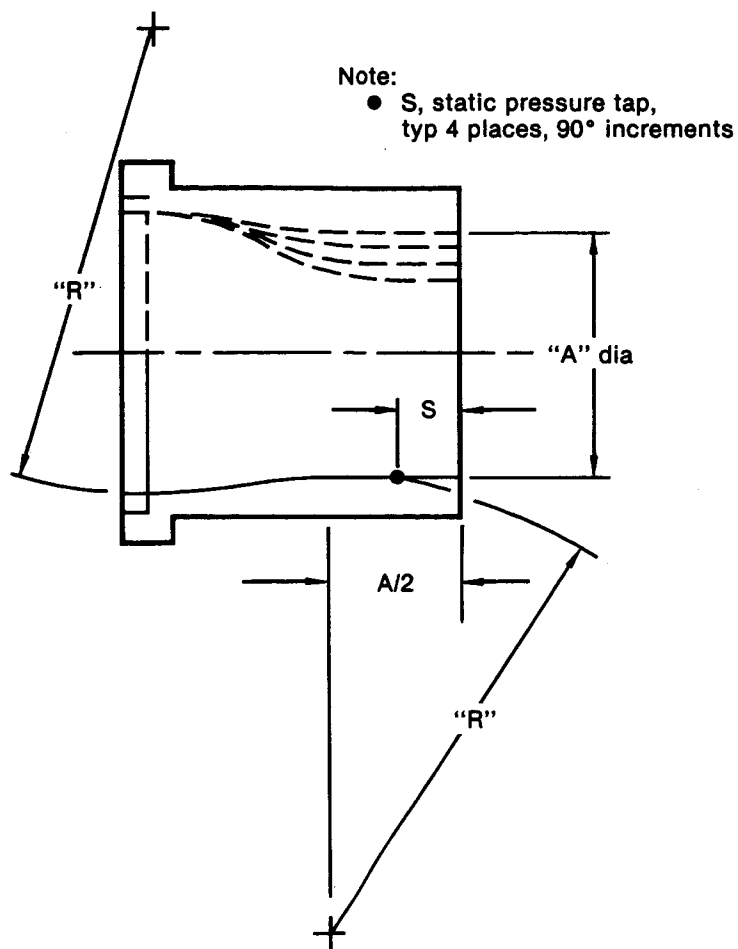
Flow-through choke data table

Configuration	Drawing	"A"	A/2	A_{throat}	"R"	"S"
1, 5	254-4452-5, -6	6.604 cm (2.600 in.)	3.302 cm (1.300 in.)	34.252 cm^2 (5.309 in.^{2})	12.637 cm (4.975 in.)	1.651 cm (0.650 in.)
2, 6	254-4452-7, -8	5.766 cm (2.270 in.)	2.883 cm (1.135 in.)	26.110 cm^2 (4.047 in.^{2})	8.273 cm (3.257 in.)	1.440 cm (0.567 in.)
3, 7	254-4452-9, -10	4.887 cm (1.924 in.)	2.443 cm (0.962 in.)	18.755 cm^2 (2.907 in.^{2})	6.711 cm (2.642 in.)	1.234 cm (0.486 in.)
4, 8	254-4452-11, -12	3.988 cm (1.570 in.)	1.994 cm (0.785 in.)	12.490 cm^2 (1.936 in.^{2})	6.005 cm (2.364 in.)	0.996 cm (0.392 in.)

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Figure 3-12. Location of Flow-Through Choke Throat Static Pressure Instrumentation

Two separate angle-of-attack measurements were made. A dangleometer mounted in the model forebody, Figure 3-7, provided one measurement of angle-of-attack. An angle-of-attack measurement was also provided which was external to the model on the support sting. The angle-of-attack based on the support sting angle required a calibration to account for elastic and thermal bending in the sting.

A potentiometer was installed in each canard drive assembly to measure the canard deflection of each of the two independently controlled canards. The potentiometers measured the canard deflection angles directly at the canard support shaft.

A strain gauge was installed in the upper surface of the left hand canard to measure the bending moment at the root.

3.2.5 Facility/CMAPS Instrumentation - Significant instrumentation was provided by the facility for measurement of airflow rates to and from the model, angle-of-attack, CMAPS health, and basic tunnel operating parameters.

In the CMAPS mode, high pressure air was delivered to the model through the drive-air passage in the sting and removed from the model through the bleed-air passage. The mass flow through each of these passages was measured with a critical flow venturi. The drive and bleed valves, operated from the simulator control console, were used to regulate the airflow.

In the Jet-Effects mode, high pressure air was delivered to the model through both the drive and the bleed passages. The drive passage airflow was also measured with a venturi. The bleed passage airflow was measured with a choked orifice flowmeter.

An apparatus called the Knuckle-Sleeve assembly which was used to measure the inclination of the support sting. These measurements were in turn used to calculate the model angle-of-attack.

Each propulsion simulator was instrumented to measure pressure, temperature, rotor thrust, vibration, and rotor speed. The simulator instrumentation was required for a combination of health monitoring and operating control. A summary of simulator instrumentation and functional use is given in Figure 3-13.

Symbol	Definition	Quantity	Connects To	Function
TBF-1	Fwd Brng Temp	1	Controller	Health/Diagnostic
TBF-2	Fwd Brng Temp	1	Backup	Health/Diagnostic
N1	Rotor Speed	1	Controller	Health/Diagnostic
N2	Rotor Speed	1	Backup	Health/Diagnostic
TBA1,2	Aft Brng Temp	2	Controller/Backup	Health/Diagnostic
RT	Rotor Thrust	1	Controller	Health/Diagnostic
PS-57	Mixer Press	1	Controller	Health/Diagnostic/ Airflow Correlation
PSK15	Comp Disch Dyn Press	1	Controller	Health/Diagnostic
TT-4	Turbine Inlet Temp	1	Controller	Health/Diagnostic
PS, PT-15	Comp Disch Press	2	Controller	W_2 (Corrected)
TT-15	Comp Disch Temp	1	Controller	W_2 (Corrected)
PT-4	Turbine Inlet Press	1	Controller	Health/Diagnostic
V1B	Vibration	1	Controller	Health/Diagnostic

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Figure 3-13. Simulator Instrumentation Summary
Per Simulator

Standard facility pressure and temperature instrumentation was provided to calculate tunnel operating conditions. These conditions included the tunnel static and total pressure, dynamic pressure, Mach number, Reynolds number, and total temperature.

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3.3 CALIBRATIONS - Complete calibrations of the installed force balance, inlet mass flow measurement, and CMAPS systems were conducted at NASA-Ames and MCAIP. These calibrations are breifly discussed in this section. A detailed description of all of the model calibrations is presented in the Phase II-Final Report, Reference 7. The CMAPS calibrations are described in References 9 and 10.

3.3.1 Force Balance Calibrations - The force balance was calibrated both isolated and installed in the model. The installed calibration results were compared with those of the isolated calibration to ensure that fouling or improper metric bridging did not occur. Pressurized loadings were also performed during the installed calibration to obtain the balance correction due to the inlet duct seal.

The isolated balance calibration was used to determine sensitivities and interactions of the six component balance to applied forces and moments. This calibration was performed by statically loading the aircraft balance at ambient pressure and temperature and at operating temperature (71°C) over the specified ranges shown in Figure 3-14. The non-standard model installation was simulated during this calibration at NASA-Ames by holding the sleeve of the balance in a non-metric support structure and applying loads to the taper end.

Gage Loaded	Range of Loadings	Increment
Axial	−113.4 − 113.4 kgf (−250 − 250 lb)	22.7 kgf (50 lb)
Normal, N1 and N2	−1,361 − 1,361 kgf (−1,361 − 1,361 lb)	272.2 kgf (600 lb)

GP53-0871-9-R

Figure 3-14. Isolated Balance Loading Schedule

The balance was then calibrated installed in the model to account for the effects of instrumentation lines and the three sets of seals (strut seal, inlet duct seal, and nozzle metric break seal). A loading fixture, shown in Figure 3-15, was attached to the upper surface of the center fuselage to which normal force, pitching moment, and axial force components were applied. Note that the model was rolled to an inverted position for the application of these loadings. Throughout the calibrations, the balance was maintained at 71°C (160°F) (the same temperature maintained during the test).

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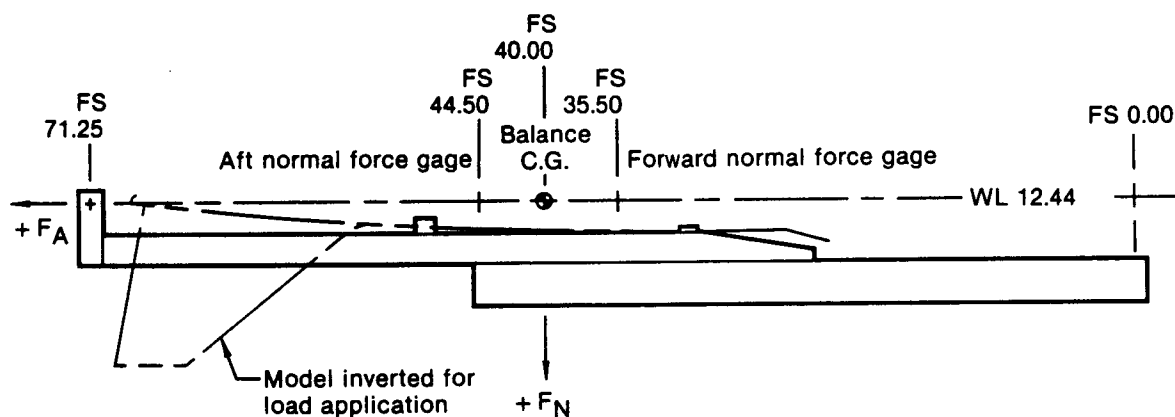
Figure 3-15. Installed Balance Loading Fixture

The installed calibrations were performed with and without a pressure differential applied across the inlet duct seal. The hardware to pressurize the inlet duct seal is shown in Figure 3-16. Small, but repeatable effects of the installation and inlet duct seal pressurization were identified by comparing the isolated and installed calibration results. An example of the intercept change and slope change which were identified in this comparison is shown in Figure 3-17.
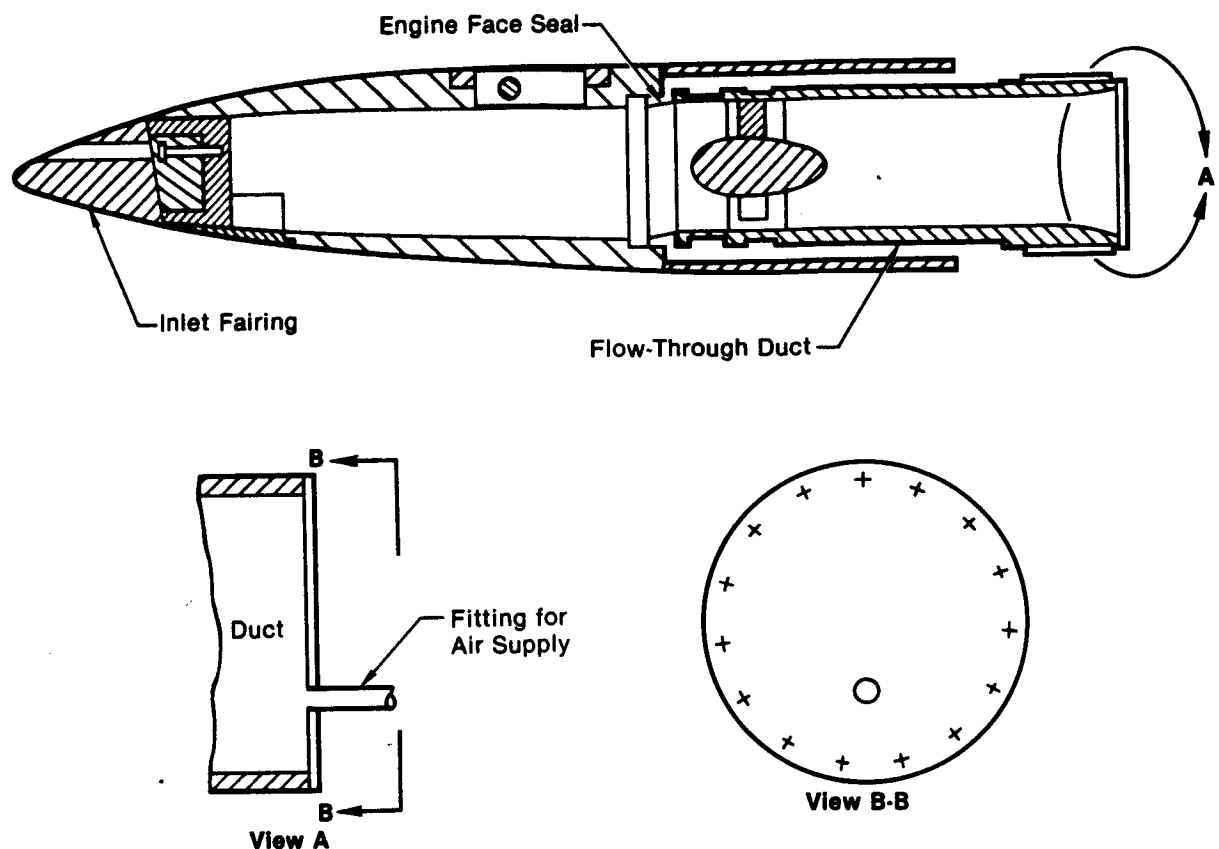
Figure 3-16. Pressurized Inlet Duct Seal Calibration Setup

GP53-0871-48-R

The change in intercept was caused by a deformation of the inlet duct seal when subjected to a pressure differential. The deformed seal exerted a force on the metric portion of the model. This force was removed from the calculated balance outputs as a tare. The contributions of this tare to axial force and pitching moment were termed FSEALA and MSEALA, respectively. The variations of these terms with the pressure differential across the duct seal (DPDS) are shown in Figures 3-18 and 3-19 for both simulator and conventional modes. The contribution to normal force was zero.

Nomenclature:

AF = Force in Axial Direction

DPDS = Pressure Differential Across Inlet Duct Seal

AFASLT = Balance Correction in Axial Direction

FSEALA = Balance Correction in Axial Direction
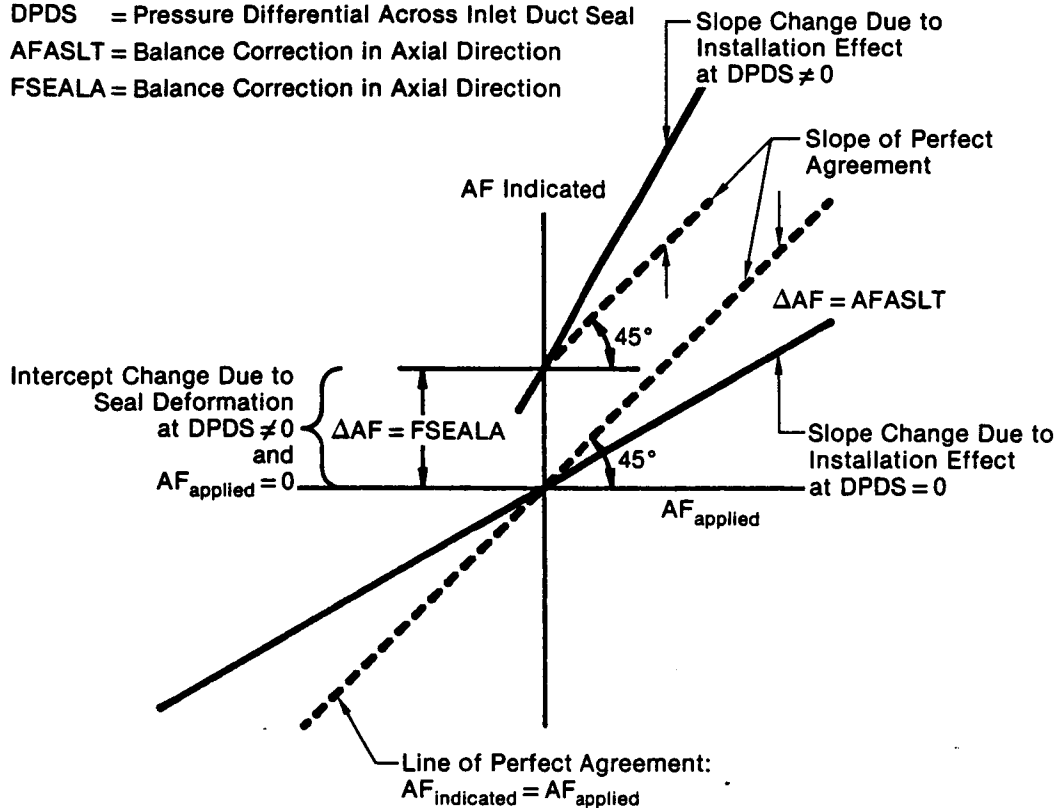
Note: Similar corrections were calculated for normal force and pitching moment

GP53-0871-7-R

Figure 3-17. Installation and Inlet Duct Seal Pressurization Corrections to Aircraft Balance In Axial Direction

The change in slope was due to the non-ideal effects of the metric seals and installation. The metric break seals and instrumentation lines which bridged the metric breaks exerted small but predictable forces on the metric portion of the model which varied with the applied load and the inlet duct seal pressure differential (DPDS). Correction terms were applied to the calculated balance outputs to account for these effects. These correction terms were labeled AFNSLT, AFASLT, and APMSLT for the contributions to normal force, axial force, and pitching moment. They are defined in Figure 3-20.

53
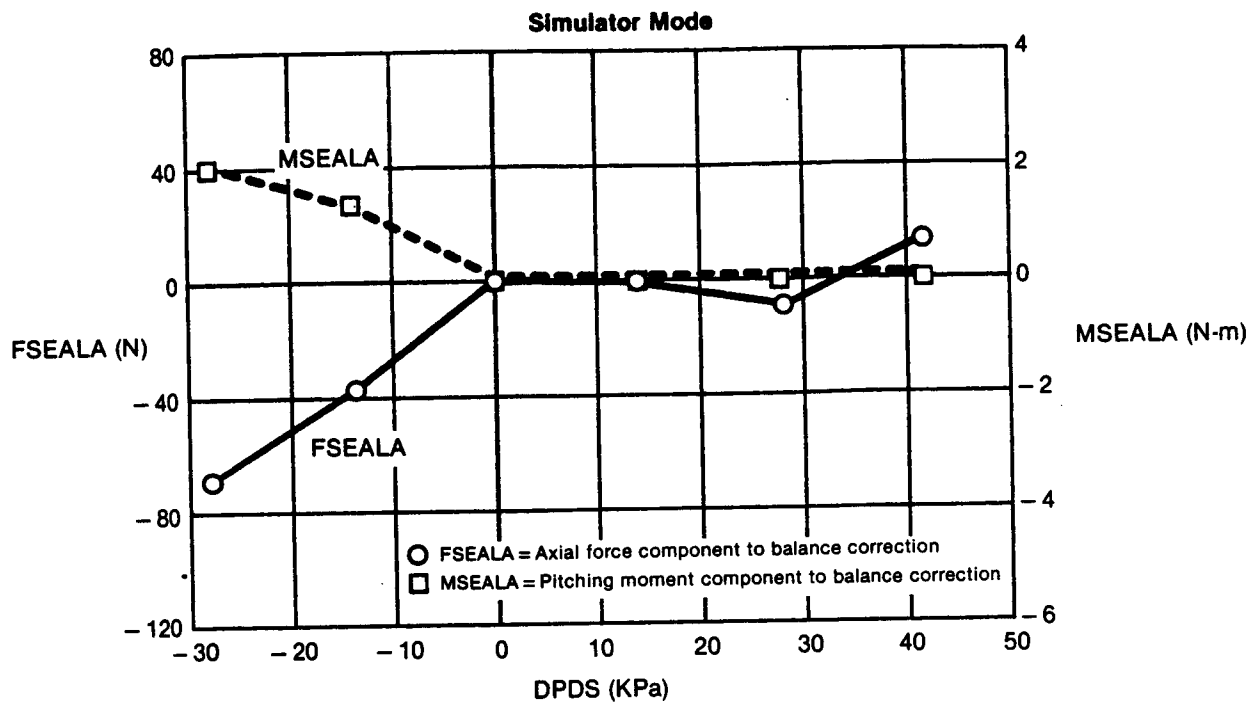
Figure 3-18. Duct Seal Pressure Effect on Balance
Simulator Mode
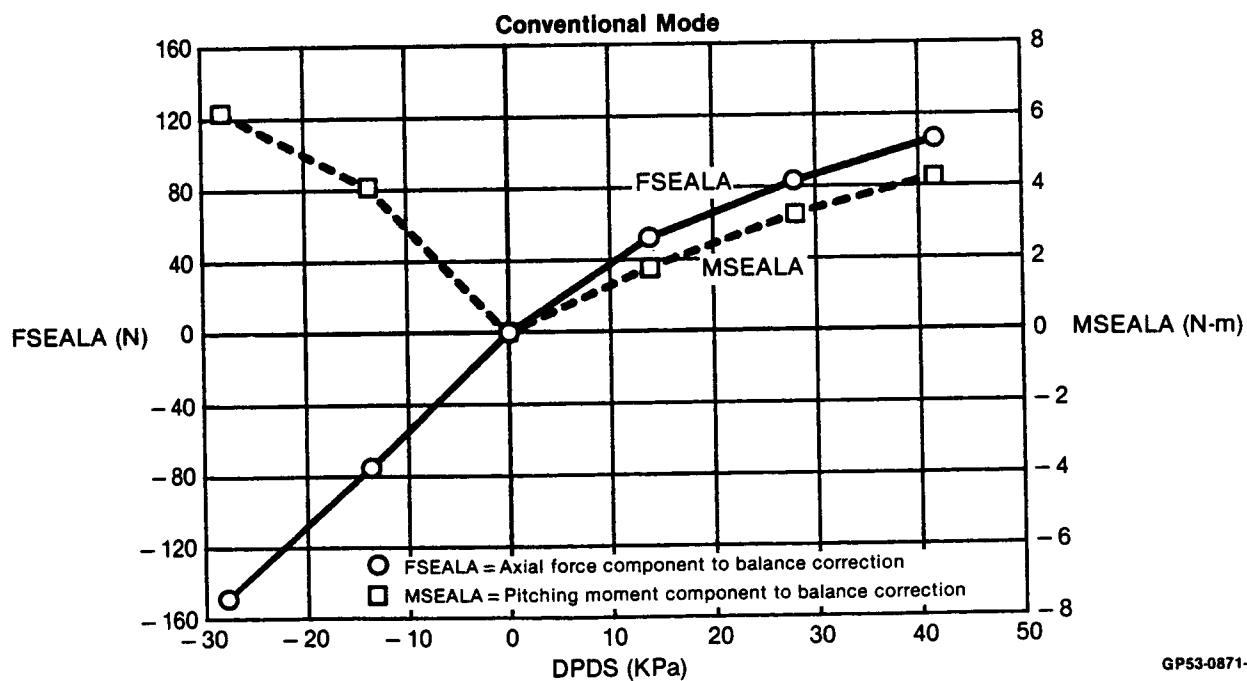
GP53-0871-6-R

Figure 3-19. Duct Seal Pressure Effect on Balance
Conventional Mode

GP53-0871-5-R

Normal Force: $\text{AFNSLT} = \text{KST28} * \text{NF} + \text{KST29} * \text{PM} + \text{KST30} * \text{AF}$

Axial Force: $\text{AFASLT} = \text{KST31} * \text{NF} + \text{KST32} * \text{PM} + \text{KST33} * \text{AF}$

Pitching Moment: $\text{APMSLT} = \text{KST34} * \text{NF} + \text{KST35} * \text{PM} + \text{KST36} * \text{AF}$

Correction Terms
Applied to Balance
Outputs

Balance Outputs:
NF = Normal Force (N)
PM = Pitching Moment (N-m)
AF = Axial Force (N)
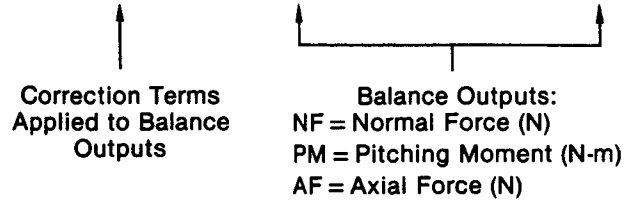
Where Values for KST Are Tabulated Below:

CMAPS Mode: Nozzle Extension Configuration (Runs 1 - 86)

	DPDS (KPa) $= P_{duct} - P_{cav}$			
	− 27.58	0	13.79	27.58
KST28 (N/N)	− 0.00289	− 0.00063	0.00480	0.00581
KST29 (N/N-m)	0.03615	0.02995	0.04517	0.05311
KST30 (N/N)	0	0	0	0
KST31 (N/N)	0.01097	0.00464	0.00641	0.01010
KST32 (N/N-m)	− 0.03556	− 0.04369	− 0.04248	− 0.03963
KST33 (N/N)	0.00741	0.00591	0.00882	0.01731
KST34 (N-m/N)	− 0.00932	− 0.00315	0.00367	− 0.00003
KST35 (N-m/N-m)	0.0589	0.00626	0.00820	0.00857
KST36 (N-m/N)	0	0	0	0

CMAPS Mode:
Simulated Aircraft and Common Baseline Configurations (Runs 87 - 293)

	DPDS (KPa)			
	− 27.58	0	13.79	27.58
KST28 (N/N)	− 0.00324	− 0.00098	0.00445	0.00546
KST29 (N/N-m)	0.02471	0.01850	0.03373	0.04165
KST30 (N/N)	0	0	0	0
KST31 (N/N)	0.00885	0.00252	0.00428	0.00798
KST32 (N/N-m)	− 0.03732	− 0.04544	− 0.04423	− 0.04137
KST33 (N/N)	0.01143	0.00993	0.01284	0.02133
KST34 (N-m/N)	− 0.00661	− 0.00044	0.00638	0.00241
KST35 (N-m/N-m)	0.0361	0.00399	0.00593	0.00629
KST36 (N-m/N)	0	0	0	0

Figure 3-20. Definition of Balance Output Correction Terms Due to Installation Effects

Flow-Through Mode:
Common Baseline Configuration (Runs 66 – 95)

	DPDS (KPa)			
	– 27.58	0	13.79	27.58
KST28 (N/N)	0.01810	0.02412	0.02515	0.02899
KST29 (N/N-m)	0.03976	0.04773	0.05550	0.06137
KST30 (N/N)	0	0	0	0
KST31 (N/N)	0.00387	0.00016	– 0.00029	0.00430
KST32 (N/N-m)	– 0.03392	– 0.03972	– 0.04130	0.04523
KST33 (N/N)	0.01311	0.01352	0.01848	0.02078
KST34 (N-m/N)	– 0.03864	– 0.02260	– 0.00991	– 0.00453
KST35 (N-m/N-m)	0.0690	0.00673	0.01079	0.01191
KST36 (N-m/N)	0	0	0	0

Flow-Through Mode:
Nozzle Extension and Nozzle Extension Baseline Configurations
(Runs 96 – 236)

	DPDS (KPa)			
	– 27.58	0	13.79	27.58
KST28 (N/N)	0.01091	0.01693	0.01796	0.02180
KST29 (N/N-m)	0.03585	0.04382	0.05160	0.05747
KST30 (N/N)	0	0	0	0
KST31 (N/N)	0.00813	– 0.00436	– 0.00584	0.00922
KST32 (N/N-m)	– 0.00907	– 0.01084	– 0.01132	– 0.01252
KST33 (N/N)	0.00824	0.00865	0.01361	0.01591
KST34 (N-m/N)	– 0.03654	– 0.02050	0.00781	– 0.00243
KST35 (N-m/N-m)	0.0563	0.00546	0.00952	0.01064
KST36 (N-m/N)	0	0	0	0

Jet-Effects Mode:
Common Baseline Configuration (Runs 237 – 321)

	DPDS (KPa)			
	– 27.58	0	13.79	27.58
KST28 (N/N)	– 0.00306	0.00296	0.00399	0.00783
KST29 (N/N-m)	0.04169	0.04966	0.05744	0.06331
KST30 (N/N)	0	0	0	0
KST31 (N/N)	– 0.00117	– 0.00498	– 0.00543	– 0.00084
KST32 (N/N-m)	– 0.02457	– 0.03037	– 0.03195	– 0.03589
KST33 (N/N)	0.01179	0.01220	0.01716	0.01946
KST34 (N-m/N)	– 0.00443	0.01161	0.02431	0.02969
KST35 (N-m/N-m)	0.0974	0.00957	0.01363	0.01475
KST36 (N-m/N)	0	0	0	0

GP53-0871-12-R

Figure 3-20. (Continued) Definition of Balance Output Correction Terms Due to Installation Effects

3.3.2 <u>Airflow Calibrations</u> - The airflow through the model was used to correct the balance outputs for axial stream thrust at Plane 2, as well as to determine inlet MFR and ram drag. The airflow calculations were based on a series of calibrations conducted by NASA-Ames and MCAIR. NASA-Ames was responsible for calibration of the CMAPS and standard facility instrumentation. MCAIR calibrated the ALBEN and nozzle extension exit chokes.

The CMAPS calibrations were conducted by NASA-Ames in their nine-by-seven-foot supersonic wind tunnel. A photo of both simulators mounted on the support sting during the static freestream airflow calibrations is shown in Figure 3-21. A bellmouth inlet, shown on the right hand CMAPS in Figure 3-21, was used to calculate the reference airflow. The bellmouth inlet was calibrated at the Colorado Engineering Experiment Station, Inc. (CEESI), as described in Reference 10. Details of the CMAPS calibration are discussed in References 9 and 10.
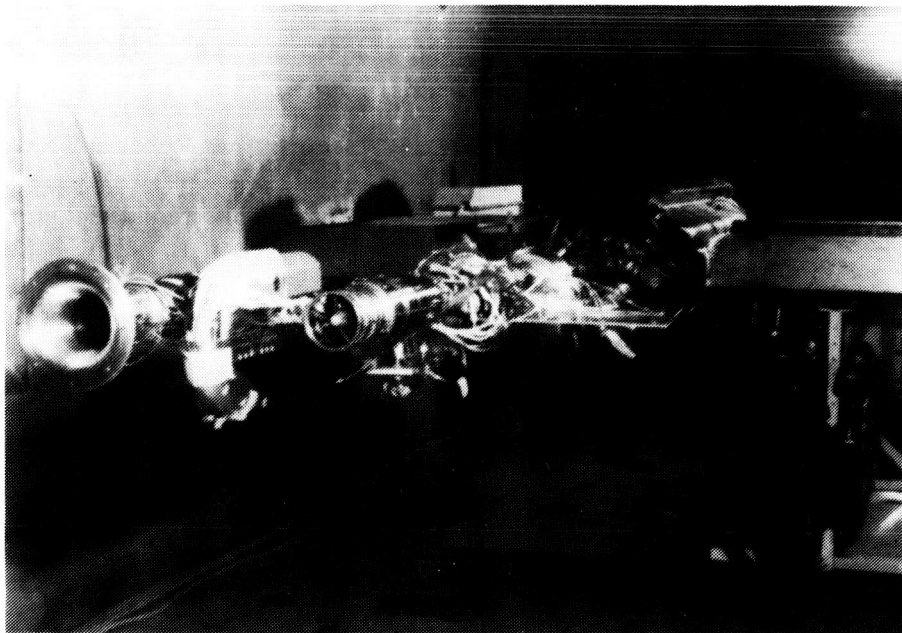
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Figure 3-21. CMAPS Compressor Airflow Calibration Set-Up

The ALBEN and nozzle extension exit chokes were both cali-
brated at the MCAIR Propulsion Subsystem Test Facility (PSTF)
located in St. Louis, Missouri. The PSTF houses the Mass Flow
Calibration System (MFCS) used in the calibration, Figure 3-22.

- 24 individual orifices each controlled by individual on/off valves
- Orifices range from 0.0156 in. dia to 2.000 in. dia
- Valve controlled manually or by computer

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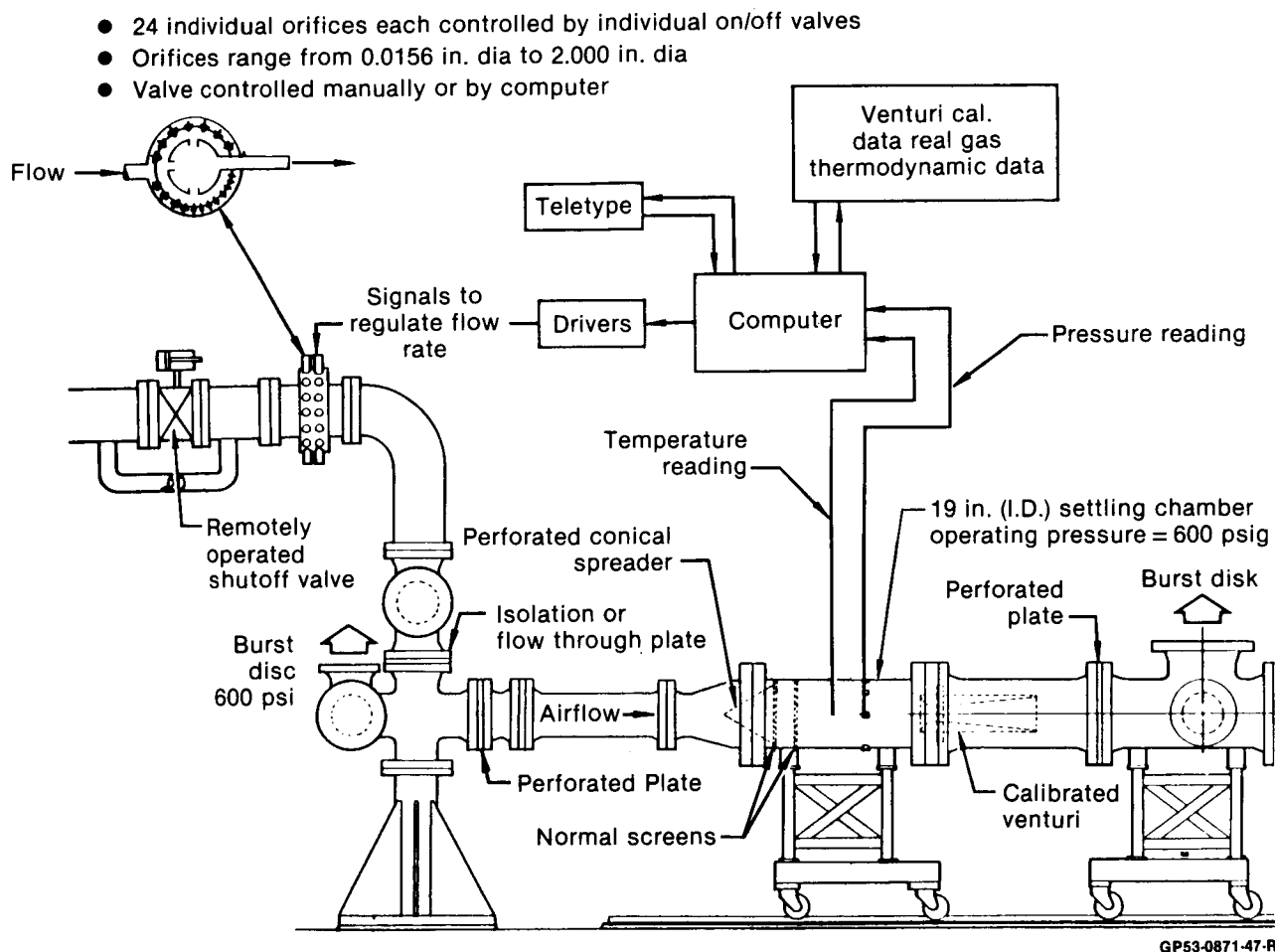
Figure 3-22. MCAIR Mass Flow Calibration Facility (MFCF)

The instrumentation for the ALBEN calibration included four
total pressure probes in the transition duct, one total tempera-
ture and total pressure in the upstream plenum, and three static
pressures on the variable external expansion ramp (VEER) of the
ALBEN.

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The instrumentation for the exit chokes included the four total pressure readings in the transition duct, nine total pressure readings in the nozzle extension tube and four static pressures from the choke throat. The instrumentation for both the ALBEN and chokes is shown in Figures 3-23 and 3-24.

Transition Duct

Nozzle Extension Tube

Forward Looking Aft

Aft Looking Forward

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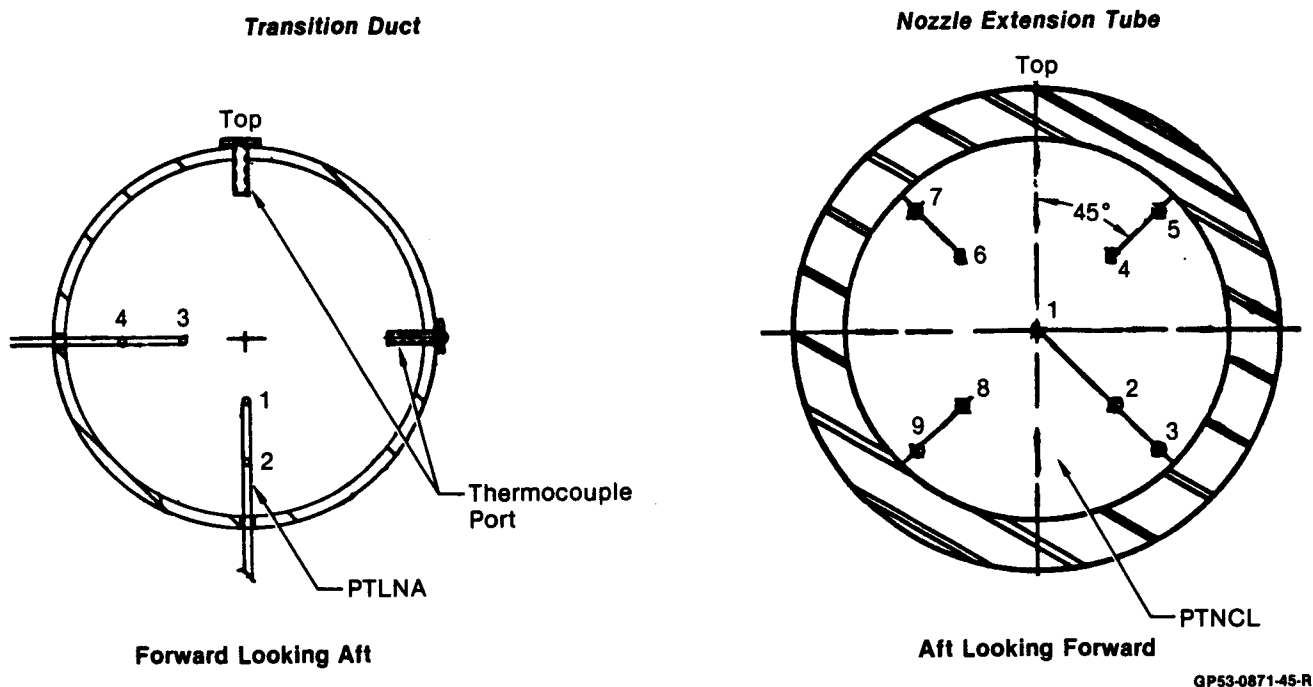
Figure 3-23. Instrumentation Used With Choke/ALBEN Calibration

Correlation of the airflow data for both ALBEN and chokes was in the form of a mass flow parameter (WTAP, Figure 3-24) versus pressure ratio. The pressure ratio for the chokes was the total pressure measured in the extension tubes divided by the static throat pressure measured in the chokes. The ALBEN correlation was based on the ratio of the transition duct total pressure and the static pressure measured by the first pressure tap on the ALBEN VEER. All airflow calibration data are presented in detail in Reference 7.
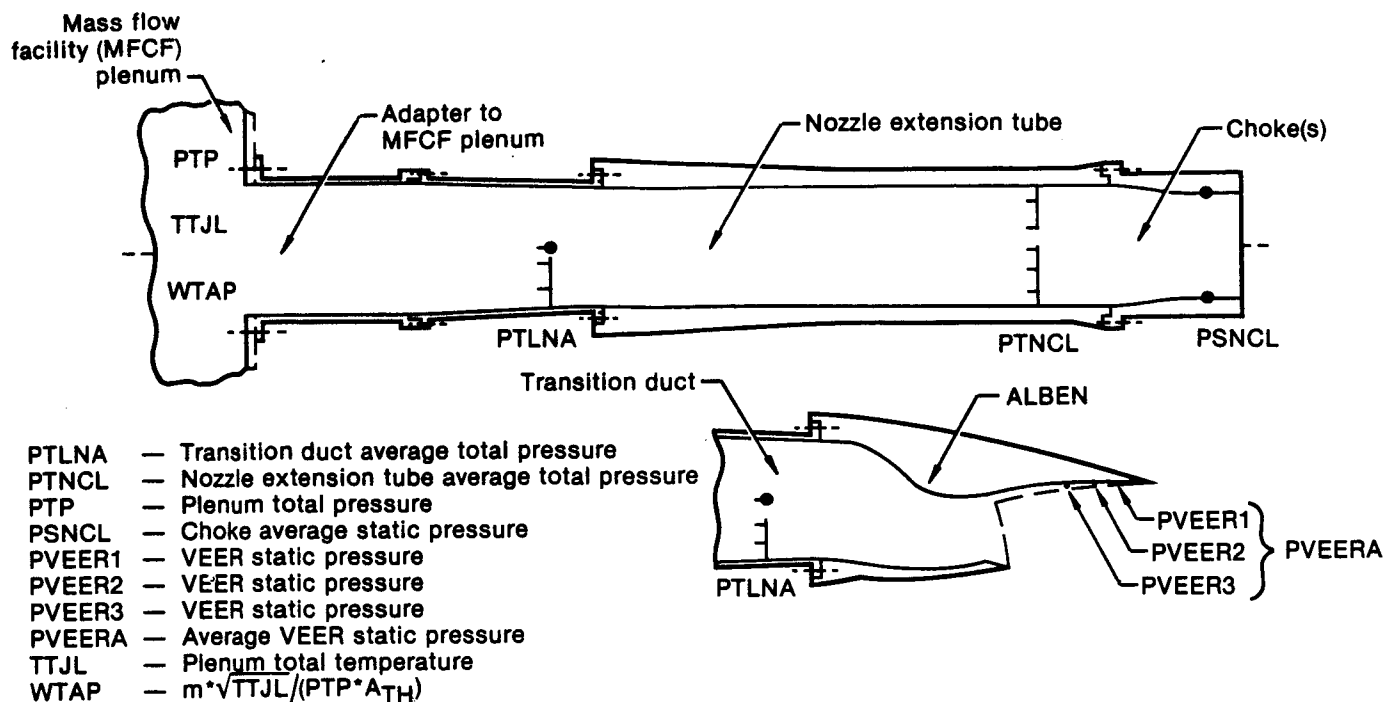
Figure 3-24. Calibration Installation and Instrumentation

During the wind tunnel tests, mass flow to and from the model was measured with facility provided venturi and orifice flowmeters (see Section 3.2.5). NASA-Ames was responsible for the standard laboratory calibration of these flowmeters.

3.4 DATA REDUCTION PROCEDURES - The data reduction effort concentrated on the calculation of aerodynamic and propulsion system performance parameters. The unique elements of the data reduction are described herein. Further discussion is presented in Reference 7. A list of the data reduction equations is included herein as Appendix C.

3.4.1 Inlet Airflow Calculation - During the Flow-Through mode testing, inlet airflow was based on measurements made in the exhaust nozzle duct (Plane 8). An indirect method of airflow calculation based on turbine discharge (Plane 57) pressure was used in the CMAPS mode.

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The Plane 8 method was based on total temperature and total and static pressure measurements at the exit chokes. These measurements were used in the one-dimensional, isentropic, compressible flow equations to directly calculate an ideal airflow at Plane 8. Flow coefficients, obtained during pre-test calibrations, were then applied to these ideal calculations to obtain the actual inlet airflow.

The Plane 57 method used in the CMAPS test mode is an indirect calculation based on a correlation of rotor speed and static pressure in the turbine discharge flow. In other words, a modified form of the engine operating map was used to determine corrected inlet airflow. The instrumentation for this pressure measurement is located in the mixer as shown in Figure 2-11. An example of corrected inlet airflow variation with rotor speed and corrected turbine discharge static pressure (PS57) is shown in Figure 3-25. Plots of this type formed the basis for the empirical correlation. This method was developed by S. C. Smith of NASA-Ames (Reference 9).
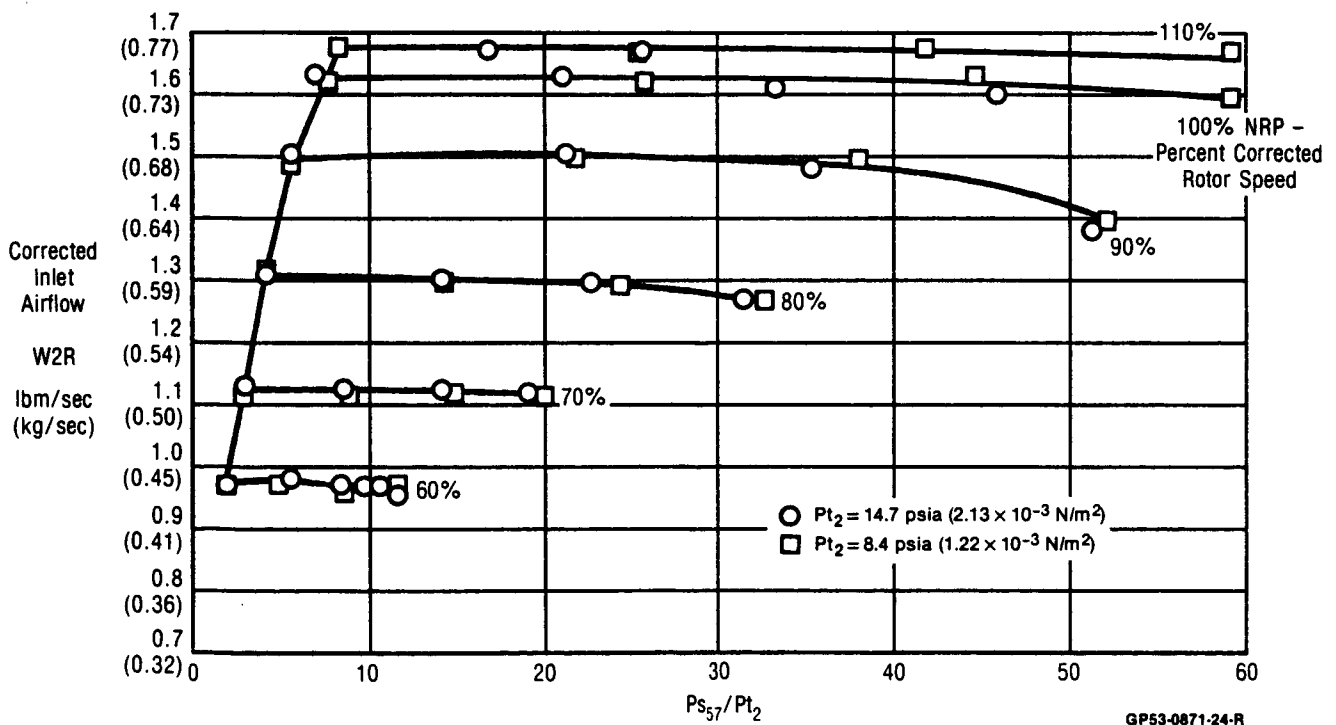
Figure 3-25. Typical CMAPS Operating Map In Terms of Turbine Discharge Pressure

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Other methods of CMAPS inlet airflow calculation were also investigated based on measurements at the engine face (Plane 2) and at the compressor discharge (Plane 15). There was also a form of the Plane 8 method investigated for the CMAPS mode. However, the Plane 57 airflow calculation was clearly shown to have the lowest uncertainty. The four methods are discussed further in Reference 2.

3.4.2 **Inlet Stream Thrust and Ram Drag** - The airflow calibration results were use to correct the balance output for the axial stream thrust at Plane 2, as well as the MFR and ram drag. The value of Plane 2 stream thrust/ram drag was based on the Plane 8 airflow method in the Flow-Through mode and the Plane 57 method in the CMAPS mode. An example of this calculation is shown in Figure 3-26. The variations of stream thrust and ram drag coefficients with angle-of-attack, MFR, and Mach number are shown in Figures 3-27 through 3-29.

3.4.3 **Force Balance Data Reduction** - Standard NASA-Ames procedures were employed to compute the basic, balance-indicated forces (normal, side, and axial) and moments (roll, pitch, and yaw).

Additional procedures were used to correct the axial force, normal force, and pitching moment outputs of the balance for seal, cavity, base, stream thrust, and ram drag tares. The application of these corrections is summarized in Appendix C.

3.4.4 **Nozzle Pressure Ratio Calculation** - The calculation of nozzle pressure (NPR) was based on the airflow through the nozzle for both CMAPS and Jet-Effects modes. Failures in the ALBEN total pressure instrumentation (PT7) prohibited direct measurement of NPR. Total airflow to each nozzle was defined as the sum of net airflow into the model from the support sting and inlet airflow.

PT2

Airflow Calculations
(Plane 8 or Plane 57)
W2C8   W2C57

V_∞ M_∞
TT_∞ P_∞

Inlet Mach Number
Interation Scheme
$M2 = f(W2, PT2, TT_\infty)$

Inlet Static
Pressure
$P2/PT2 = f(M2)$

Inlet Stream
Thrust
$FS = A2[P2(\gamma M2^2 + 1) - P_\infty]$

Inlet Ram
Drag
$FRAM = W2 * V_\infty$

$$MFR = \frac{W2 * (TT_\infty)^{1/2}}{A1 * P_\infty * MDOT}$$

Nomenclature

W2C8	= Inlet Airflow From Plane 8 Method	A2	= Plane 2 Area
		A1	= Inlet Capture Area
W2C57	= Inlet Airflow From Plane 57 Method	TT_∞	= Freestream Total Temperature
P2	= Inlet Static Pressure	P_∞	= Freestream Static Pressure
PT2	= Inlet Total Pressure	V_∞	= Freestream Velocity
M2	= Inlet Mach Number	MDOT	= $f(M_\infty)$

GP53-0871-4-R

Figure 3-26. Example of Inlet Stream Thrust, Ram Drag, and MFR Calculation
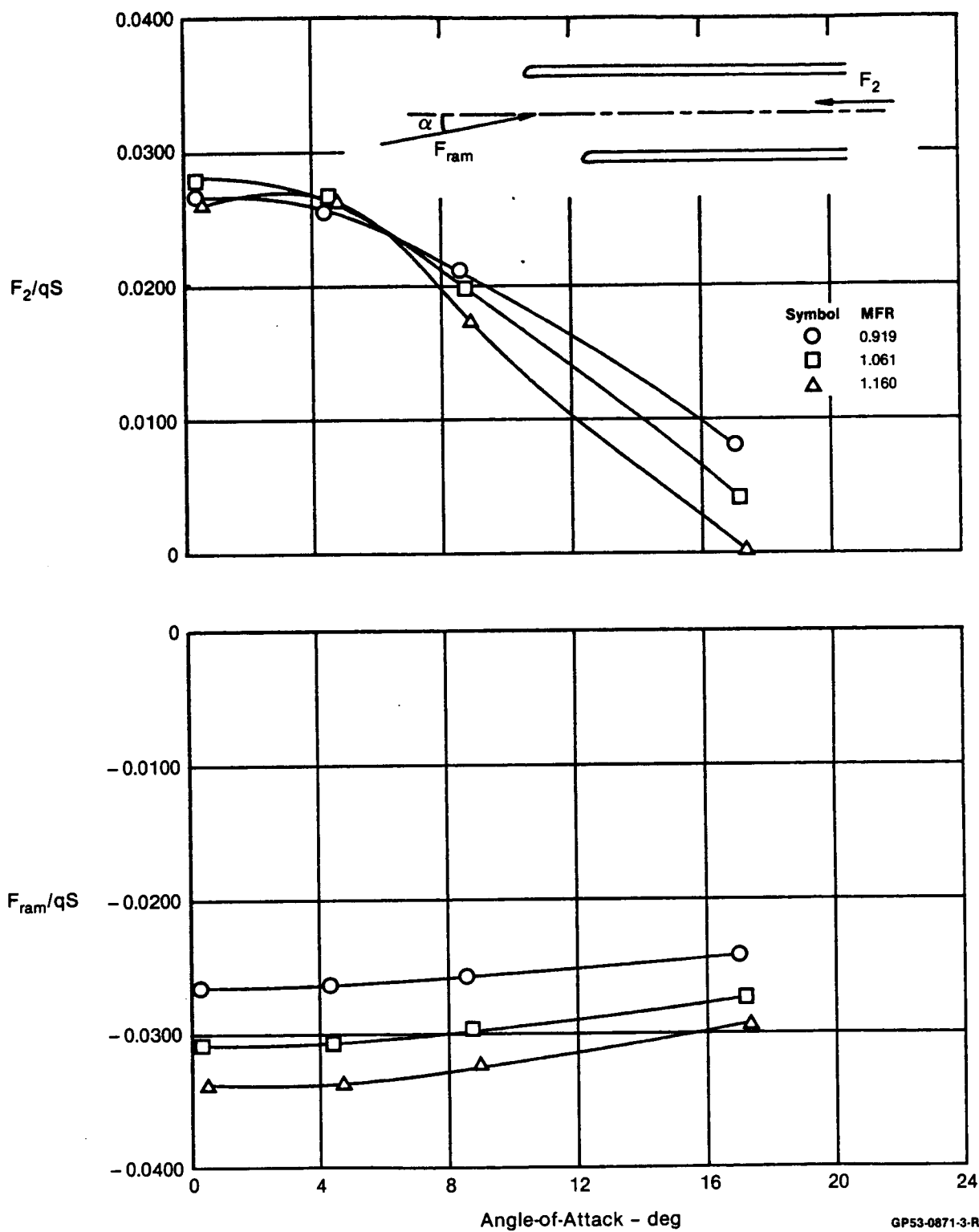
Figure 3-27. Variation of Stream Thrust and Ram Drag Coefficients
CMAPS Mode   Mach 0.4
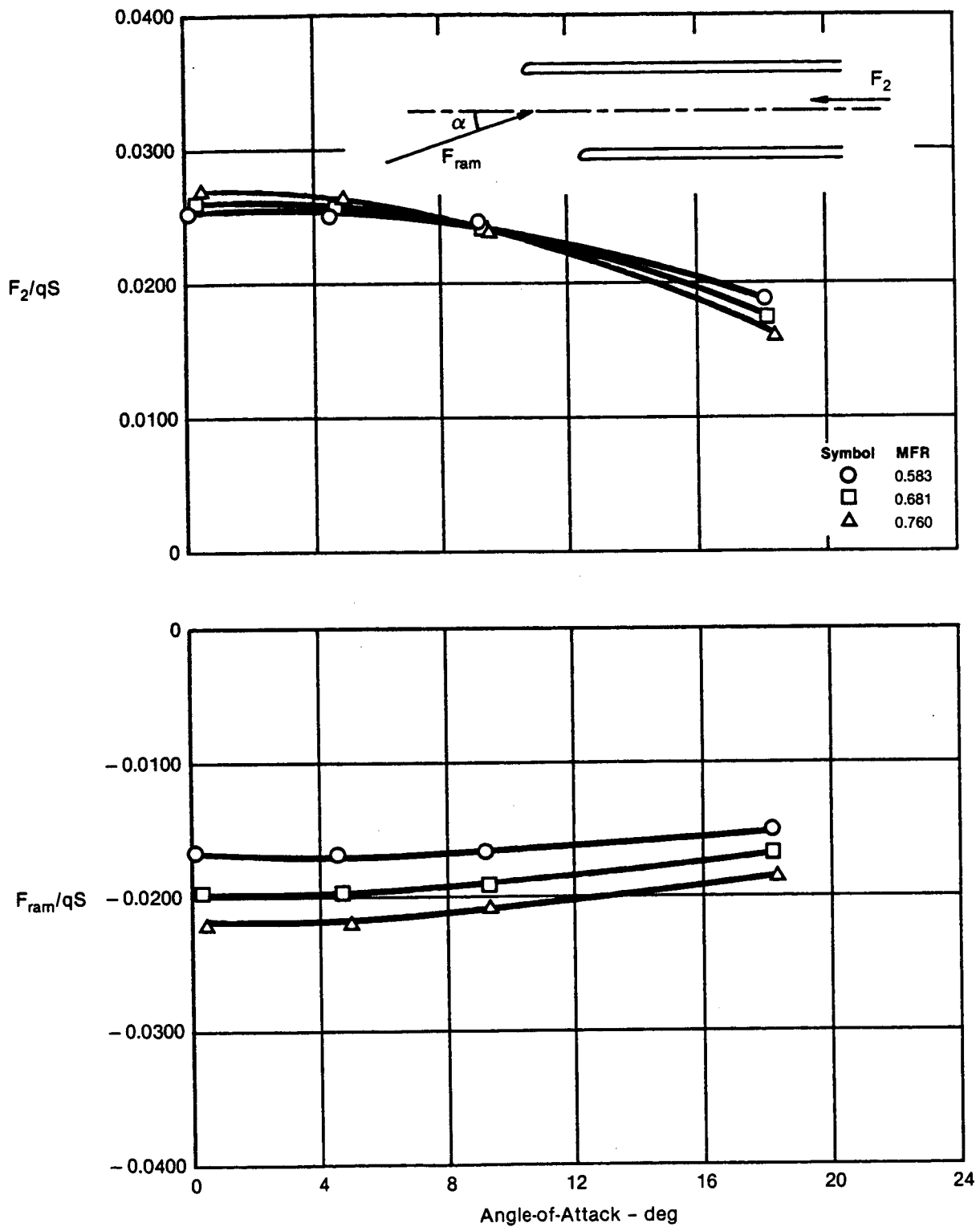
GP53-0871-3-R

Figure 3-28. Variation of Stream Thrust and Ram Drag Coefficients
CMAPS Mode   Mach 0.9

GP53-0871-2-R
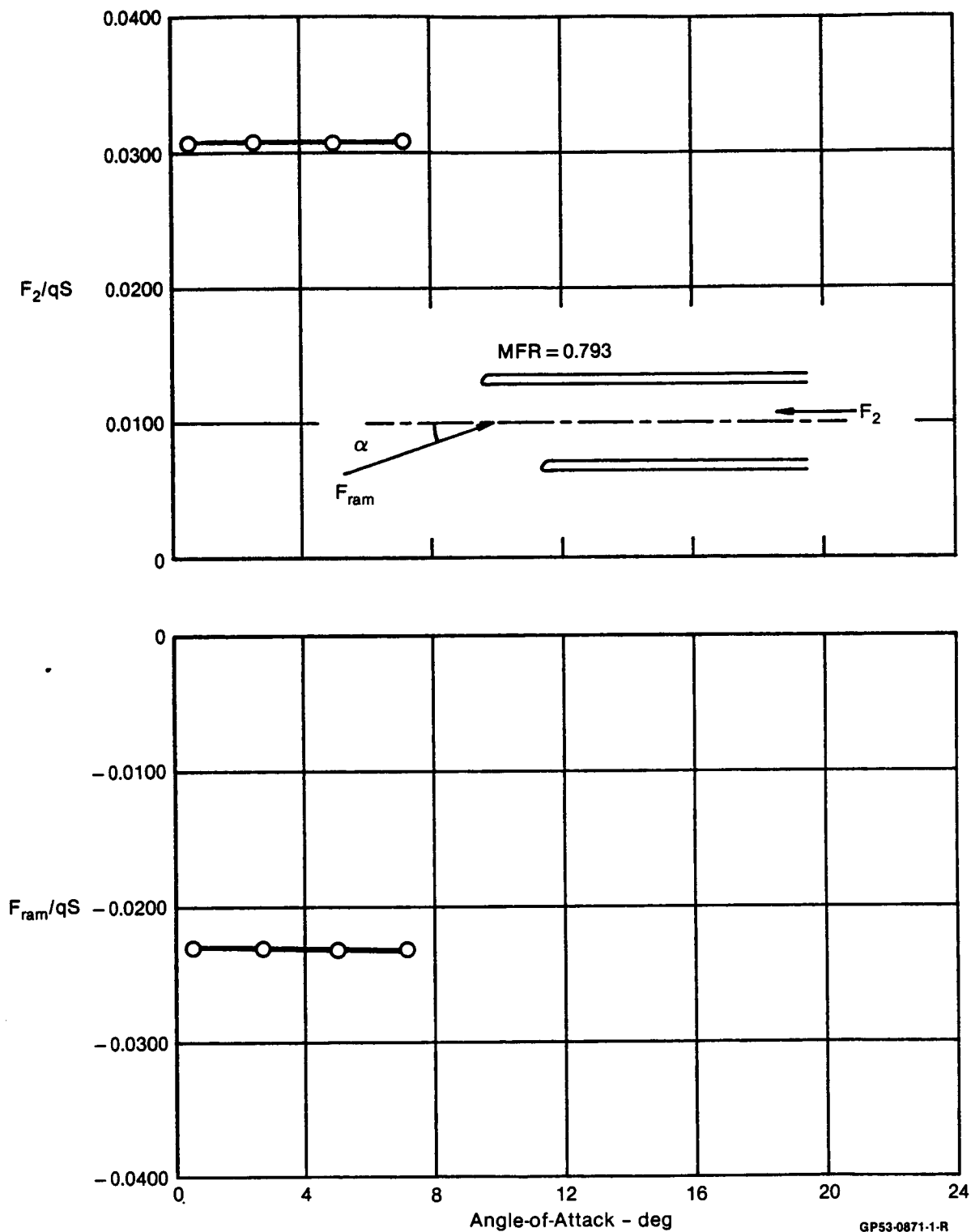
Figure 3-29. Variation of Stream Thrust and Ram Drag Coefficients
CMAPS Mode   Mach 1.4

GP53-0871-1-R

For the CMAPS mode, the net airflow through the sting was the difference between the drive-line and bleed-line airflows, measured with critical flow venturi flowmeters. The value used for inlet airflow was based on the Plane 57 method described in Section 3.4.1.

For the Jet-Effects mode, total nozzle airflow was defined as the sum of drive-line and bleed-line airflows. (There is, of course, no inlet flow in the Jet-Effects mode.) The drive-line airflow was again measured with a venturi. The bleed-line airflow was based on an empirical correlation. Failure of the bleed-line airflow metering system early in the Jet-Effects mode test necessitated such a correlation. Airflow measurements made prior to the instrumentation failure were correlated with corresponding manifold pressure and total temperature. These correlation equations were then used to calculate bleed-line airflow. This predicted airflow was used for all the Jet-Effects runs as the bleed-line contribution to the total nozzle airflow. The correlation equations are included in Appendix C.

The pre-test airflow calibrations performed on the ALBEN by MCAIR and the total temperature measurements in the transition duct provided the means of calculating NPR from nozzle airflow. The calibration curves are presented in Reference 7.

4. REFERENCES

1. Zilz, D.E. and Devereaux, P.A., "Propulsion and Airframe Aerodynamic Interactions of Supersonic V/STOL Configurations - Volume I: Wind Tunnel Test Pressure Data Report", NASA CR-177343, September 1985.

2. Zilz, D. E.; Wallace, H. W.; and Hiley, P. E.; Propulsion and Airframe Aerodynamic Interactions of Supersonic V/STOL Configurations - Volume III: Wind Tunnel Test Data Analysis Report", NASA CR-177343, September.

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7. Booher, M.E., "Propulsion and Airframe Aerodynamic Interactions of Supersonic V/STOL Configurations: Phase II - Final Report", NASA CR-177370, September 1985.

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9. Smith, S.C., "Determining Compressor Inlet Airflow in the Compact Multimission Aircraft Propulsion Simulators in Wind Tunnel Applications", AIAA Paper 83-1231, June 1983.

10. Bailey, R.O., "Propulsion Simulation Test Technique for V/STOL Configurations", SAE Paper 83-1427, October 1983.

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APPENDIX A

WIND TUNNEL TEST RESULTS: FORCE AND MOMENT DATA

The basic force and moment data is presented graphically as lift, drag, and pitching moment coefficients. These coefficients are plotted in a manner which reflects the main variable during each run. Since most of the runs consisted of angle-of-attack (AOA) sweeps, the general plot format is to present C_L versus C_D, AOA, and C_M. The data which was acquired during nozzle pressure ratio (NPR) sweeps is presented as C_L, C_D and C_M versus NPR. The following plots of lift, drag, and pitching moment coefficients are therefore presented in two categories either angle-of-attack sweeps or nozzle pressure ratio sweeps.

The lifting characteristics of the canard are also presented here graphically. The left-hand canard was instrumented with a single strain gage near the root, Figure A-1, which was calibrated to measure a spanwise bending moment. The canard root bending moment coefficient ($C_{m_{CRB}}$) is an indirect indication of the canard's lifting properties.

A.1 <u>ANGLE-OF-ATTACK SWEEPS</u> - The force and moment plots are grouped to show the effects of various inlet, nozzle and control surface configurations over an angle-of-attack range. Each of these configurations is presented in a series of three plots. These three plots are as follows:

    (1) C_L -vs- C_D

    (2) C_L -vs- AOA

    (3) C_L -vs- C_M

The forces on the nozzle extensions were not included in the total lift, drag, and pitching moment coefficients. Therefore, the plots which include the Nozzle Extension or Nozzle Extension

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Baseline Configurations are based on the airframe lift, drag, and pitching moment coefficients denoted here as CLA, CDA, and CMA.

Following is an index of the force and moment plots from the angle-of-attack sweeps.
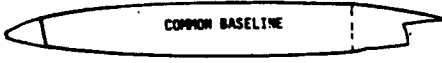
Inlet Mass Flow Ratio Effects

Configuration	Test Mode	Mach	NPR	δ_c	Pages
NOZZLE EXTENSION COWL LIP = 0° δ_F = 0°	F/T	0.4	N/A	-5°	78-79
		0.6			80-81
		0.9			82-83
		1.2			84-85
		1.4	↓	↓	86-87
COWL LIP = 45° δ_F = 30°	F/T	0.4	N/A	0°	88-89
COWL LIP = 0° δ_F = 0°	CMAPS	0.4	N/A	0°	90-91
		0.6			92-93
		0.9			94-95
		1.2			96-97
		1.4	↓	↓	98-99
SIMULATED AIRCRAFT ALBEN A/B δ_N = 0°	CMAPS	0.4	1.3	0°	100-101
		0.9	2.0	0°	102-103

Nozzle Pressure Ration Effects

Configuration	Test Mode	Mach	MFR	δ_c	Pages
COMMON BASELINE ALBEN DRY δ_N = 0°	J/E	0.4	N/A	-5°	104-105
		0.6			106-107
		0.9	↓	↓	108-109
ALBEN A/B δ_N = 0°	J/E	0.4	N/A	-5°	110-111
		0.6		-5°	112-113
		0.9		-5°	114-115
		1.2		0°	116-117
		1.4	↓	0°	118-119
SIMULATED AIRCRAFT ALBEN A/B δ_N = 0°	CMAPS	0.4	1.15	0°	120-121
		0.6	0.92	-5°	122-123
		0.9	0.75	-5°	124-125
		1.2	0.69	0°	126-127
		1.4	0.72	0°	128-129

NPR Effects With Thrust Vectoring

Configuration	Test Mode	Mach	MFR	δ_c	Pages
COMMON BASELINE	J/E	0.4	N/A	−5°	130−131
		0.6		−5°	132−133
ALBEN A/B		0.9	↓	−5°	134−135
$\delta_N = 20°$		1.2		0°	136−137
ALBEN A/B $\delta_N = 30°$ $\delta_F = 30°$	J/E	0.4	N/A	−5°	138−139

Nozzle Vectoring Effects

Configuration	Test Mode	Mach	NPR	δ_c	Pages
COMMON BASELINE	J/E	0.4	4.1	−5°	140−141
		0.6	4.2	↓	142−143
$\delta_N = 0° - vs - \delta_N = 20°$		0.9	6.2	−5°	144−145
$\delta_N = 0°$ $- vs - \delta_N = 30°$ $\delta_F = 0°$ $\delta_F = 30°$	J/E	0.4	4.1	−5°	146−147

Power Setting Effects

Configuration	Test Mode	Mach	NPR	δ_c	Pages
COMMON BASELINE	J/E	0.6	4.2	−5°	148−149
		0.9	6.7	−5°	150−151
Dry−vs−A/B					

Canard Rotation Effects

Configuration	Test Mode	Mach	MFR	NPR	Pages
NOZZLE EXTENSION	F/T	0.4	1.20	N/A	152−153
		0.6	0.92		154−155
COWL LIP = 0° $\delta_F = 0°$		0.9	0.87	↓	156−157
		1.2	0.89		158−159
		1.4	0.93		160−161

Candard Rotation Effects (Continued)

Configuration: COMMON BASELINE — ALBEN A/B $\delta_N = 0°$; SIMULATED AIRCRAFT — ALBEN A/B $\delta_N = 0°$

Test Mode	Mach	MFR	NPR	Pages
F/T	0.4	N/A	1.0	162-163
	0.6			164-165
	0.9			166-167
	1.2			168-169
	1.4			170-171
CMAPS	0.4	1.15	2.8	172-173
	0.6	0.91	3.8	174-175
	0.9	0.75	5.4	176-177
	1.2	0.75	7.5	178-179
	1.4	0.79	9.6	180-181

Wing Flap and Cowl Lip Deflection Effects

Configuration: NOZZLE EXTENSION

Test Mode	Mach	MFR	NPR	δ_C	Pages
F/T	0.4	1.11	N/A	0°	182-183

Cowl Lip Deflection Effects

Configuration: NOZZLE EXTENSION

Test Mode	Mach	MFR	NPR	δ_C	Pages
F/T	0.6	0.85	N/A	-5°	184-185
	0.9	0.85			186-187

Nozzle Extension Effects
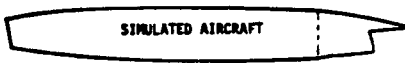
Configuration: NOZZLE EXTENSION BASELINE — vs — COMMON BASELINE

Test Mode	Mach	MFR	NPR	δ_C	Pages
F/T	0.4	N/A	N/A	-5°	188-189
	0.6			-5°	190-191
	0.9			-5°	192-193
	1.2			0°	194-195
	1.4			0°	196-197

<div align="center">

Common Baseline Comparison

</div>

Configuration	Test Mode	Mach	MFR	NPR	δ_C	Pages
COMMON BASELINE ALBEN A/B $\delta_N = 0°$	FT, JE, CMAPS	0.4	N/A	1.0	-5°	198-199
		0.6			-5°	200-201
		0.9			-5°	202-203
		1.2			0°	204-205
		1.4			0°	206-207

A.2 <u>NPR SWEEPS</u> - The throttle dependent effects on lift, drag, and pitching moment are presented in this section. Nozzle and total configuration force and moment data is plotted versus nozzle pressure ratio.

<div align="center">

Inlet Mass Flow Ratio Effects

</div>

Configuration	Test Mode	Mach	δ_C	α	Pages
SIMULATED AIRCRAFT ALBEN A/B $\delta_N = 0°$	CMAPS	0.6	-5°	0°	208-209
				4.5°	210-211
				9°	212-213
				17.5°	214-215

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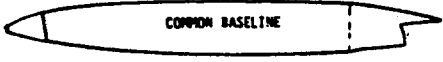
Angle of Attack Effects

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Test Mode	Mach	δ_C	MFR	Pages
CMAPS	0.6	-5°	0.91	216-217

<div align="center">

Canard Rotation Effects

</div>

Test Mode	Mach	MFR	α	Pages
CMAPS	0.6	0.69	0°	218-219
		0.91	0°	220-221
		0.61	17.5°	222-223
		0.75	17.5°	224-225

Nozzle Vectoring Effects

Configuration	Test Mode	Mach	δ_c		Pages
COMMON BASELINE	J/E	0.4	−5°	0°	226−227
		0.6	−5°		228−229
ALBEN A/B		0.9	−5°		230−231
		1.2	0°	↓	232−233

Power Setting Effects

Configuration	Test Mode	Mach	δ_c		Pages
COMMON BASELINE	J/E	0.4	−5°	0°	234−235
ALBEN A/B vs		0.6	↓	↓	236−237
ALBEN Dry		0.9			238−239

A.3 <u>CANARD ROOT BENDING MOMENT</u> − The effects of canard deflection angle, MFR, and NPR variations on the canard root bending moment ($C_{m_{CRB}}$) are presented in this section. All of the plots are in the form of $C_{M_{CRB}}$ versus angle-of-attack.

Canard Rotation Effects

Configuration	Test Mode	Mach	MFR	NPR	Pages
COMMON BASELINE	FT	0.4	N/A	1.0	240
		0.6			241
ALBEN A/B		0.9			242
$\delta_N = 0°$		1.2			243
		1.4	↓	↓	244
	FT	0.4	1.10	N/A	245
		0.6	0.92		246
		0.9	0.87		247
		1.2	0.89		248
		1.4	0.92	↓	249
SIMULATED AIRCRAFT	CMAPS	0.4	1.15	2.8	250
		0.6	0.91	3.8	251
ALBEN A/B		0.9	0.75	5.4	252
$\delta_N = 0°$		1.2	0.75	7.5	253
		1.4	0.79	9.6	254
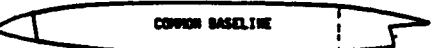
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Mass Flow Ratio Effects

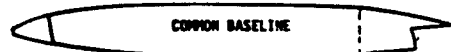| Configuration	Test Mode	Mach	NPR	δ_C	Pages
NOZZLE EXTENSION COWL LIP = 0° δ_F = 0°	FT	0.4	N/A	−5°	255
		0.6		−5°	256
		0.9	↓	−5°	257
		1.2		0°	258
		1.4		0°	259
SIMULATED AIRCRAFT ALBEN A/B δ_N = 0°	CMAPS	0.4	1.3	0°	260
		0.9	4.4	0°	261

Nozzle Pressure Ratio Effects

Configuration	Test Mode	Mach	MFR	δ_C	Pages
COMMON BASELINE ALBEN A/B δ_N = 0°	JE	0.4	N/A	−5°	262
		0.6		−5°	263
		0.9	↓	−5°	264
		1.2		0°	265
		1.4		0°	266
SIMULATED AIRCRAFT ALBEN A/B δ_N = 0°	CMAPS	0.4	1.16	−5°	267
		0.6	0.92	0°	268
		0.9	0.76	−5°	269
		1.2	0.69	0°	270
		1.4	0.72	0°	271

Nozzle Vectoring Effects

Configuration	Test Mode	Mach	NPR	δ_C	Pages
COMMON BASELINE ALBEN A/B δ_N = 0° −vs− δ_N = 20°	JE	0.4	4.0	−5°	272
		0.6	4.2	−5°	273
		0.9	6.2	−5°	274

INLET MASS FLOW RATIO EFFECTS ON CLA VS CDA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
□	514	188	0.3999	0.5546	-4.9989
△	514	206	0.3982	0.8216	-4.9948
◇	514	178	0.3988	1.164	-4.9726
⊙	514	167	0.4016	1.1343	-4.9956

INLET MASS FLOW RATIO EFFECTS ON CLA VS AOA AND CMA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
☐	514	188	0.3999	0.5546	-4.9989
▲	514	206	0.3982	0.8216	-4.9948
◇	514	178	0.3988	1.1164	-4.9726
⊙	514	167	0.4016	1.1343	-4.9956

INLET MASS FLOW RATIO EFFECTS ON CLA VS CDA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
▢	514	112	0.5970	0.3531	-4.9087
▲	514	137	0.5997	0.5265	-4.9685
◇	514	152	0.5987	0.7036	-4.9599

CLA

1.2
1.0
0.8
0.6
0.4
0.2
0.0

-0.02 0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14 0.16 0.18

CDA
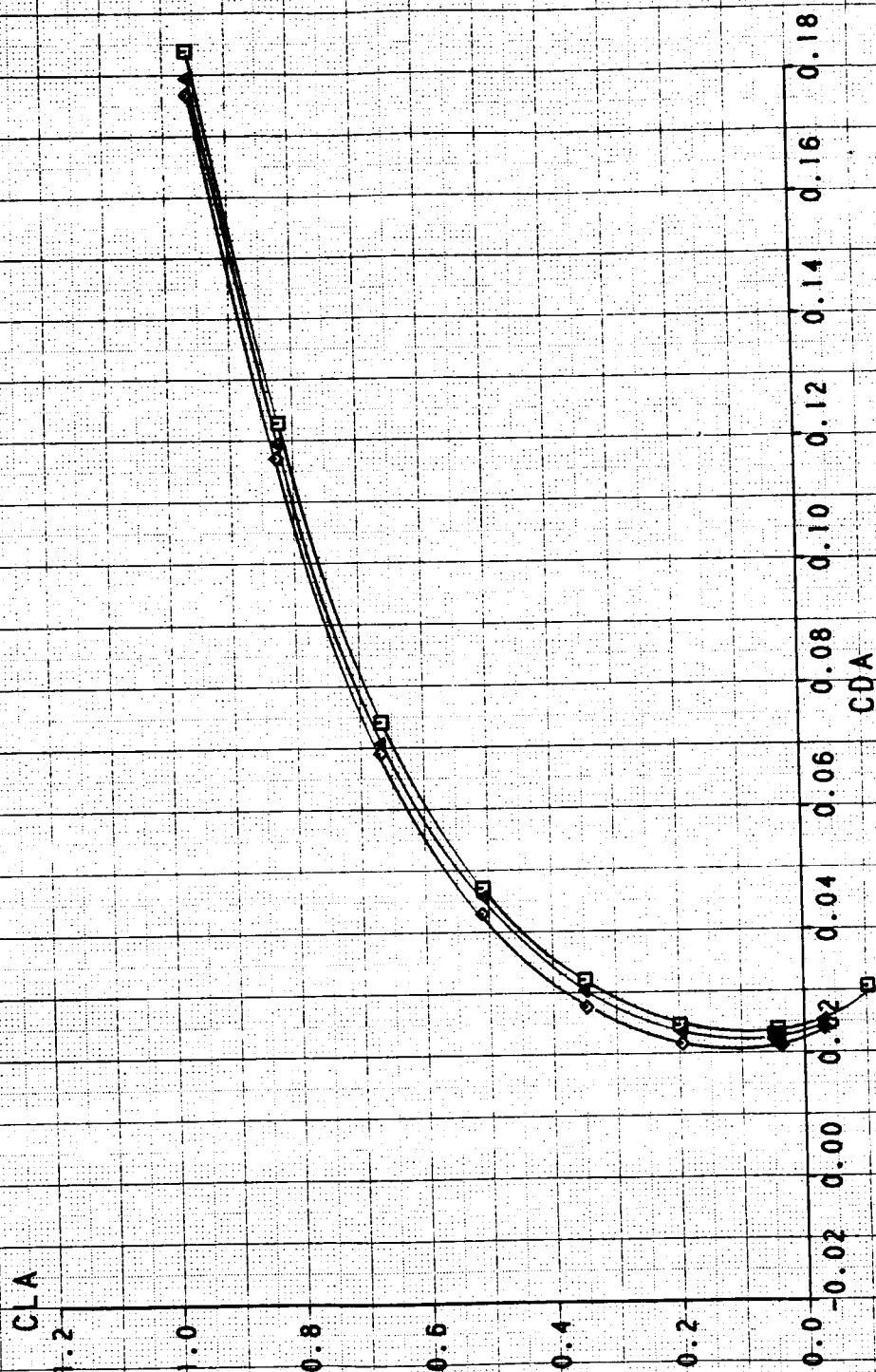
INLET MASS FLOW RATIO EFFECTS ON CLA VS AOA AND CMA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
▢	514	112	0.5970	0.3531	-4.9087
▲	514	137	0.5997	0.5265	-4.9685
◇	514	152	0.5987	0.7036	-4.9599

INLET MASS FLOW RATIO EFFECTS ON CLA VS CDA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
□	514	117	0.9000	0.3485	-4.9149
▲	514	133	0.9018	0.5176	-4.9635
◇	514	147	0.9018	0.7063	-4.9854
⊕	514	156	0.9022	0.8692	-4.9921

INLET MASS FLOW RATIO EFFECTS ON CLA VS AOA AND CMA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
□	514	117	0.9000	0.3485	-4.9149
△	514	133	0.9018	0.5176	-4.9635
◇	514	147	0.9018	0.7063	-4.9854
⊕	514	156	0.9022	0.8692	-4.9921

INLET MASS FLOW RATIO EFFECTS ON CLA VS CDA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RWFR	RDELCL
□	514	120	1.2012	0.3525	-4.9670
▲	514	130	1.985	0.5223	-4.9605
◇	514	144	1.1979	0.7103	-4.9762
⊖	514	159	1.1977	0.8895	-4.9745

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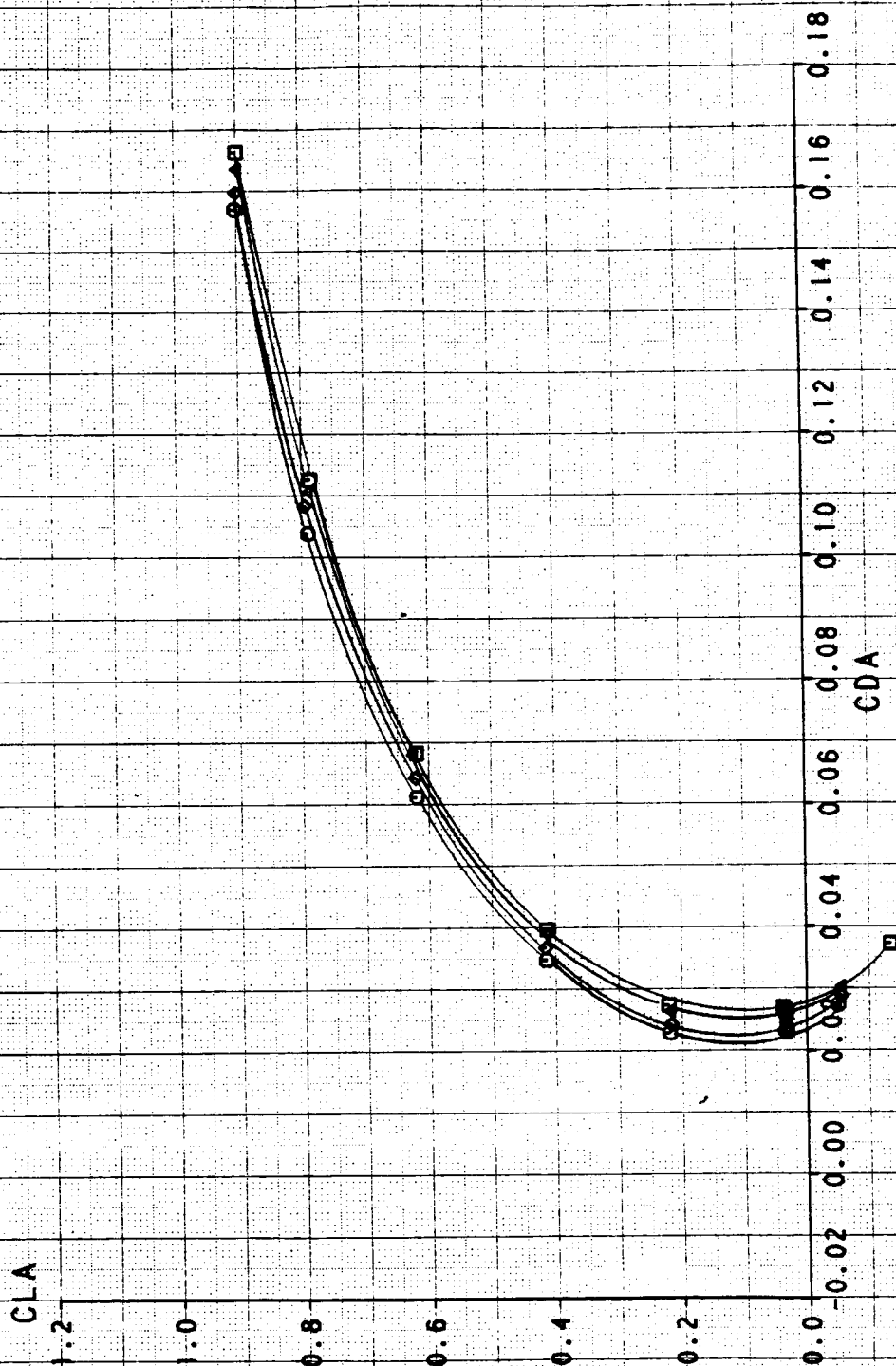
INLET MASS FLOW RATIO EFFECTS ON CLA VS AOA AND CMA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
□	514	120	1.2012	0.3525	-4.9670
△	514	130	1.1985	0.5223	-4.9605
◇	514	144	1.1979	0.7103	-4.9762
○	514	159	1.1977	0.8895	-4.9745

CLA

CMA

CLA

ANGLE OF ATTACK

c-2

85
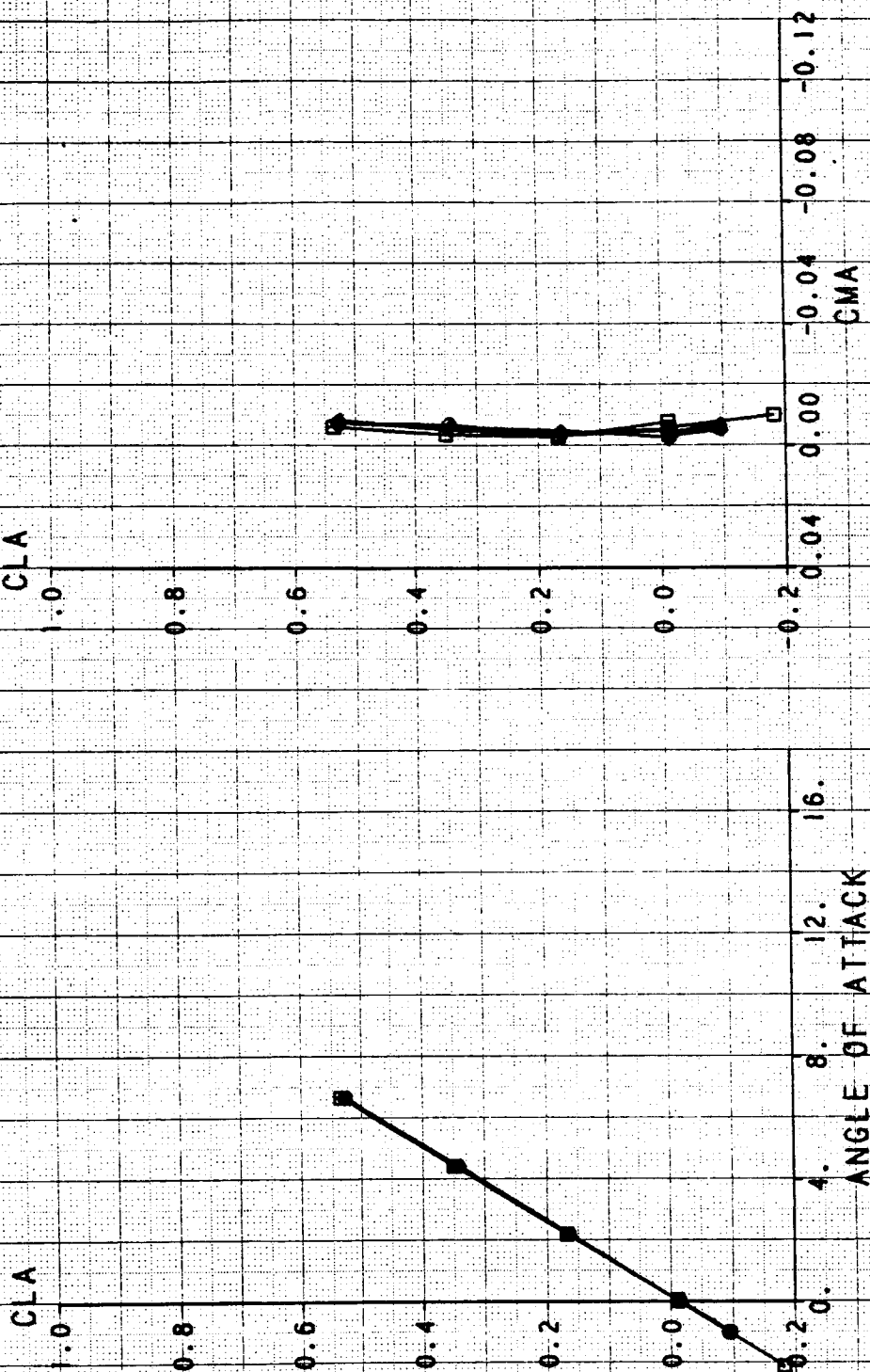
INLET MASS FLOW RATIO EFFECTS ON CLA VS CDA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
☐	514	123	1.3879	0.3651	-4.9636
▲	514	127	1.3944	0.5440	-4.9658
◇	514	143	1.3977	0.7424	-4.9978
⊖	514	162	1.3939	0.9261	-4.9931

INLET MASS FLOW RATIO EFFECTS ON CLA VS AOA AND CMA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
▢	514	123	1.3879	0.3651	-4.9636
▲	514	127	1.3944	0.5440	-4.9658
◆	514	143	1.3977	0.7424	-4.9978
⊖	514	162	1.3939	0.9261	-4.9931

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INLET MASS FLOW RATIO EFFECTS ON CLA VS CDA
FT MODE WITH 45 DEG COWL LIP AND 30 DEG WING FLAPS

SYM	TEST	RUN	RMACH	RMFR	RDELCL	DESCRIPTION
□	514	197	0.3989	0.5527	-0.0145	FLOW-THROUGH MODE WITH DROOP-LIP INLET
▲	514	202	0.3993	0.7757	-0.0343	FLOW-THROUGH MODE WITH DROOP-LIP INLET
◇	514	199	0.3992	1.1076	-0.0211	FLOW-THROUGH MODE WITH DROOP-LIP INLET

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INLET MASS FLOW RATIO EFFECTS ON CLA VS AOA AND CMA
FT MODE WITH 45 DEG COWL LIP AND 30 DEG WING FLAPS

SYM	TEST	RUN	RMACH	RMFR	RDELCL	DESCRIPTION
□	514	197	0.3989	0.5527	-0.0145	FLOW-THROUGH MODE WITH DROOP-LIP INLET
△	514	202	0.3993	0.7757	-0.0343	FLOW-THROUGH MODE WITH DROOP-LIP INLET
◇	514	199	0.3992	1.1076	-0.0211	FLOW-THROUGH MODE WITH DROOP-LIP INLET

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INLET MASS FLOW RATIO EFFECTS ON CLA VS CDA
SIMULATOR MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
▢	514	30	0.3993	0.5172	.00369
◄	514	31	0.4006	0.7838	-0.0167
◇	514	32	0.4003	1.0662	-4.6E-4
⊕	514	33	0.3988	1.1759	-8.4E-4

INLET MASS FLOW RATIO EFFECTS ON CLA VS AOA AND CMA
SIMULATOR MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
☐	514	30	0.3993	0.5172	.00369
▲	514	31	0.4006	0.7838	-0.0167
◇	514	32	0.4003	1.0662	-4.6E-4
⊙	514	33	0.3988	1.1759	-8.4E-4

INLET MASS FLOW RATIO EFFECTS ON CLA VS CDA
SIMULATOR MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
□	514	47	0.5993	0.3851	.00859
△	514	52	0.5999	0.5868	-2.9E-4
◇	514	53	0.6004	0.8067	-.00348
⊕	514	54	0.5994	0.9176	-.00725

CLA

1.0
0.8
0.6
0.4
0.2
0.0
-0.2

CDA

-0.2 0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14 0.16 0.18 0.20

INLET MASS FLOW RATIO EFFECTS ON CLA VS AOA AND CMA
WITH NOZZLE EXTENSIONS SIMULATOR MODE

SYM	TEST	RUN	RMACH	RWFR	RDELCL
□	514	47	0.5993	0.3851	.00859
△	514	52	0.5999	0.5868	2.9E-4
◇	514	53	0.6004	0.8067	-.00348
○	514	54	0.5994	0.9176	-.00725

CLA

CMA

CLA

ANGLE OF ATTACK

93

INLET MASS FLOW RATIO EFFECTS ON CLA VS CDA
SIMULATOR MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
□	514	59	0.8980	0.3255	-.0136
△	514	60	0.8959	0.4953	-.00809
◇	514	61	0.9030	0.6834	-.00120
⊕	514	62	0.9032	0.8687	-0.0289

94

INLET MASS FLOW RATIO EFFECTS ON CLA VS AOA AND CMA
SIMULATOR MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
□	514	59	0.8980	0.3255	-0.0136
△	514	60	0.8959	0.4953	-.00809
◇	514	61	0.9030	0.6834	-0.0120
⊙	514	62	0.9032	0.8687	-0.0289

CLA

CMA

CLA

ANGLE OF ATTACK

INLET MASS FLOW RATIO EFFECTS ON CLA VS CDA
SIMULATOR MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
□	514	71	1.1954	0.3316	0.0152
▲	514	72	1.1965	0.5032	-.00222
◇	514	73	1.1933	0.6928	-.00509
⊖	514	74	1.1951	0.8779	-.00617

INLET MASS FLOW RATIO EFFECTS ON CLA VS AOA AND CMA
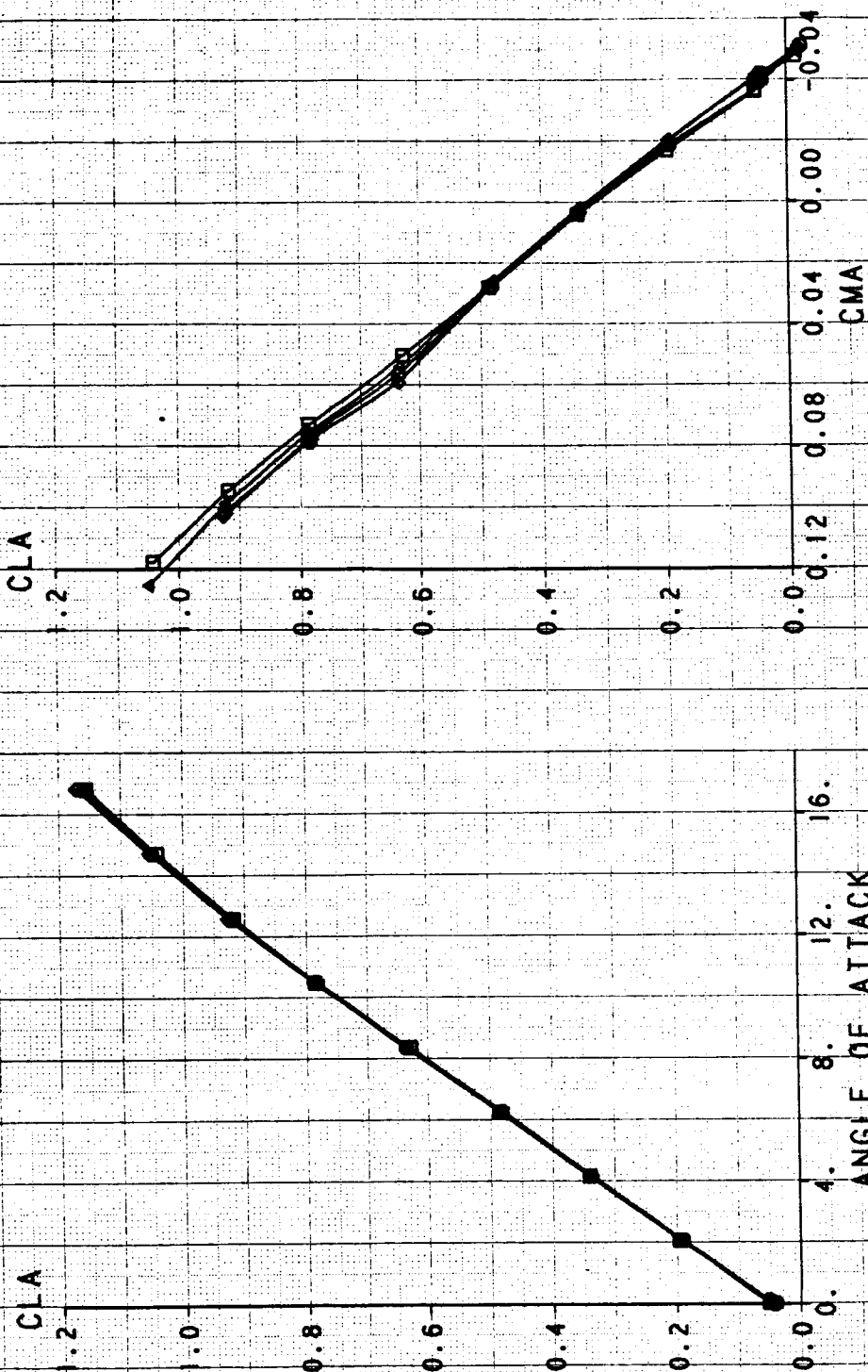SIMULATOR MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
□	514	71	1.1954	0.3316	0.0152
△	514	72	1.1965	0.5032	-.00222
◇	514	73	1.1933	0.6928	-.00509
○	514	74	1.1951	0.8779	-.00617

CLA

CMA

CLA

ANGLE OF ATTACK

INLET MASS FLOW RATIO EFFECTS ON CLA VS CDA
SIMULATOR MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
□	514	79	1.4023	0.3477	-0.03322
▲	514	80	1.4014	0.5283	-0.02204
◇	514	81	1.4016	0.7284	-0.0157
⊖	514	82	1.4012	0.9303	-.00617

CLA

CDA

1.0   0.8   0.6   0.4   0.2   0.0   -0.2

-0.20   0.00   0.02   0.04   0.06   0.08   0.10   0.12   0.14   0.16   0.18   0.20

INLET MASS FLOW RATIO EFFECTS ON CLA VS AOA AND CMA
SIMULATOR MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
□	514	79	1.4023	0.3477	-0.0322
△	514	80	1.4014	0.5283	-0.0204
◇	514	81	1.4016	0.7284	-0.0157
⊙	514	82	1.4012	0.9303	-.00617

CLA

CMA

CLA

ANGLE OF ATTACK

99

INLET MASS FLOW RATIO EFFECTS ON SIMULATOR MODE DRAG POLAR
WITH UNVECTORED A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RMFR	RDELCL
□	514	265	0.4019	1.3322	0.7801	0.1531
▲	514	266	0.4019	1.3145	0.9176	0.1562
◆	514	269	0.4023	1.2816	1.0552	0.1520

INLET MASS FLOW RATIO EFFECTS ON CL VS AOA AND CM
SIMULATOR MODE WITH UNVECTORED A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RMFR	RDELCL
□	514	265	0.4019	1.3322	0.7801	0.1531
△	514	266	0.4019	1.3145	0.9176	0.1562
◇	514	269	0.4023	1.2816	1.0552	0.1520

INLET MASS FLOW RATIO EFFECTS ON SIMULATOR MODE DRAG POLAR
WITH UNVECTORED A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RMFR	RDELCL
□	514	192	0.9021	4.4266	0.6751	0.1239
▲	514	196	0.9042	4.3951	0.7568	0.0938
◇	514	200	0.9052	4.2850	0.8685	0.1250

102

INLET MASS FLOW RATIO EFFECTS ON CL VS AOA AND CM
SIMULATOR MODE WITH UNVECTORED A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RMFR	RDELCL
□	514	192	0.9021	4.4266	0.6751	0.1239
△	514	196	0.9042	4.3951	0.7568	0.0938
◇	514	200	0.9052	4.2850	0.8685	0.1250

103

NOZZLE PRESSURE RATIO EFFECT ON DRAG POLAR
JET-EFFECTS MODE WITH UNVECTORED DRY ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
□	514	303	0.3977	0.1022	-5.0162
△	514	305	0.3985	6.9133	-4.9686

104

NOZZLE PRESSURE RATIO EFFECT ON CL VS AOA AND CM
JET-EFFECTS MODE WITH UNVECTORED DRY ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
⊡	514	303	0.3977	0.1022	-5.0162
▲	514	305	0.3985	6.9133	-4.9686

NOZZLE PRESSURE RATIO EFFECT ON DRAG POLAR
JET-EFFECTS MODE WITH UNVECTORED DRY ALBEN
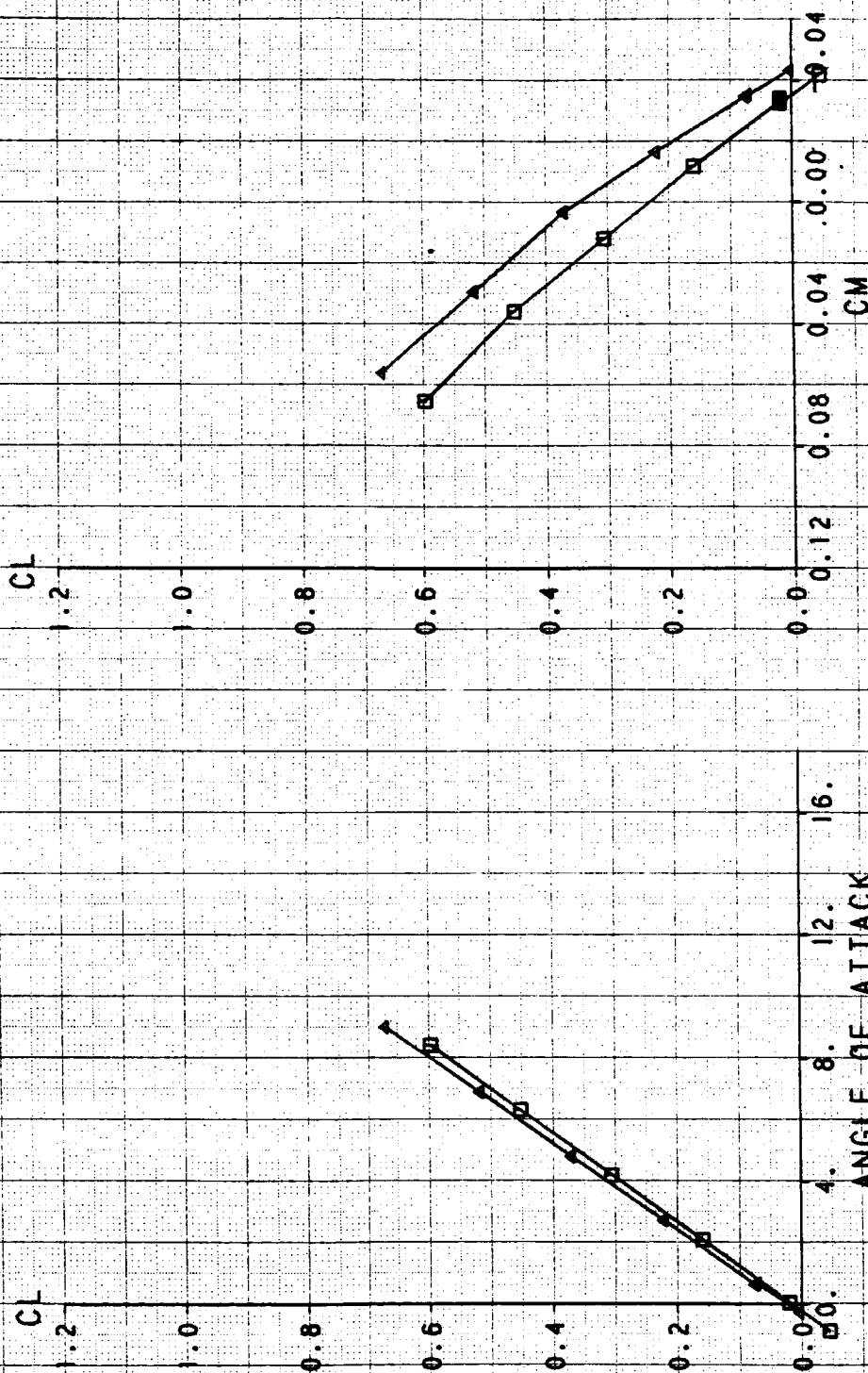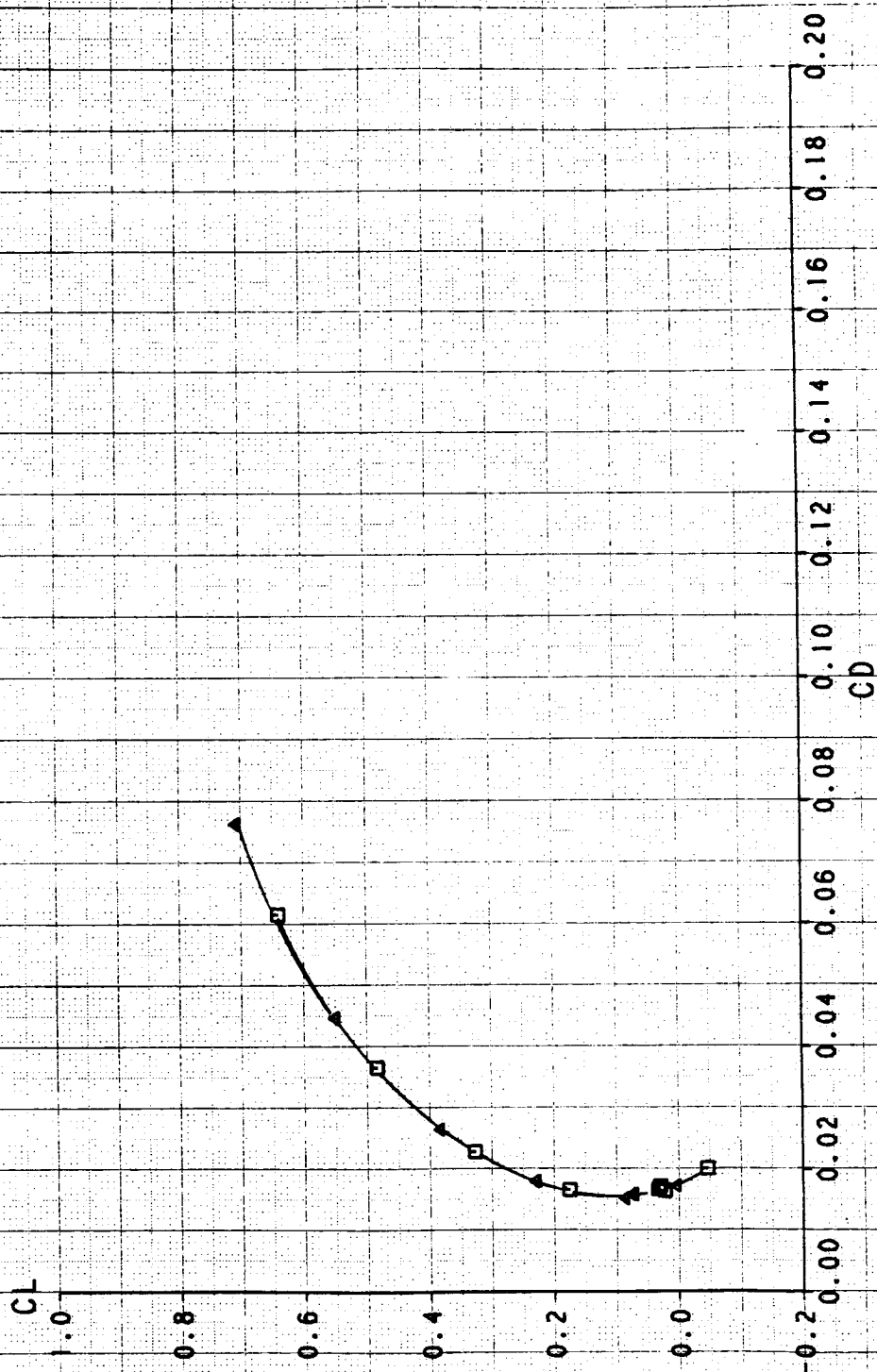
SYM	TEST	RUN	RMACH	RNPRA	RDELCL
□	514	312	0.5997	0.1435	-4.9709
▲	514	314	0.6001	4.6697	-4.9617

NOZZLE PRESSURE RATIO EFFECT ON CL VS AOA AND CM
JET-EFFECTS MODE WITH UNVECTORED DRY ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
▢	514	312	0.5997	0.1435	-4.9709
▲	514	314	0.6001	4.6697	-4.9617

107

NOZZLE PRESSURE RATIO EFFECT ON DRAG POLAR
JET-EFFECTS MODE WITH UNVECTORED DRY ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
□	514	319	0.9002	0.2180	-4.9679
▲	514	315	0.8992	6.7075	-4.9260

NOZZLE PRESSURE RATIO EFFECT ON CL VS AOA AND CM
JET-EFFECTS MODE WITH UNVECTORED DRY ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
□	514	319	0.9002	0.2180	-4.9679
▲	514	315	0.8992	6.7075	-4.9260

NOZZLE PRESSURE RATIO EFFECT ON DRAG POLAR
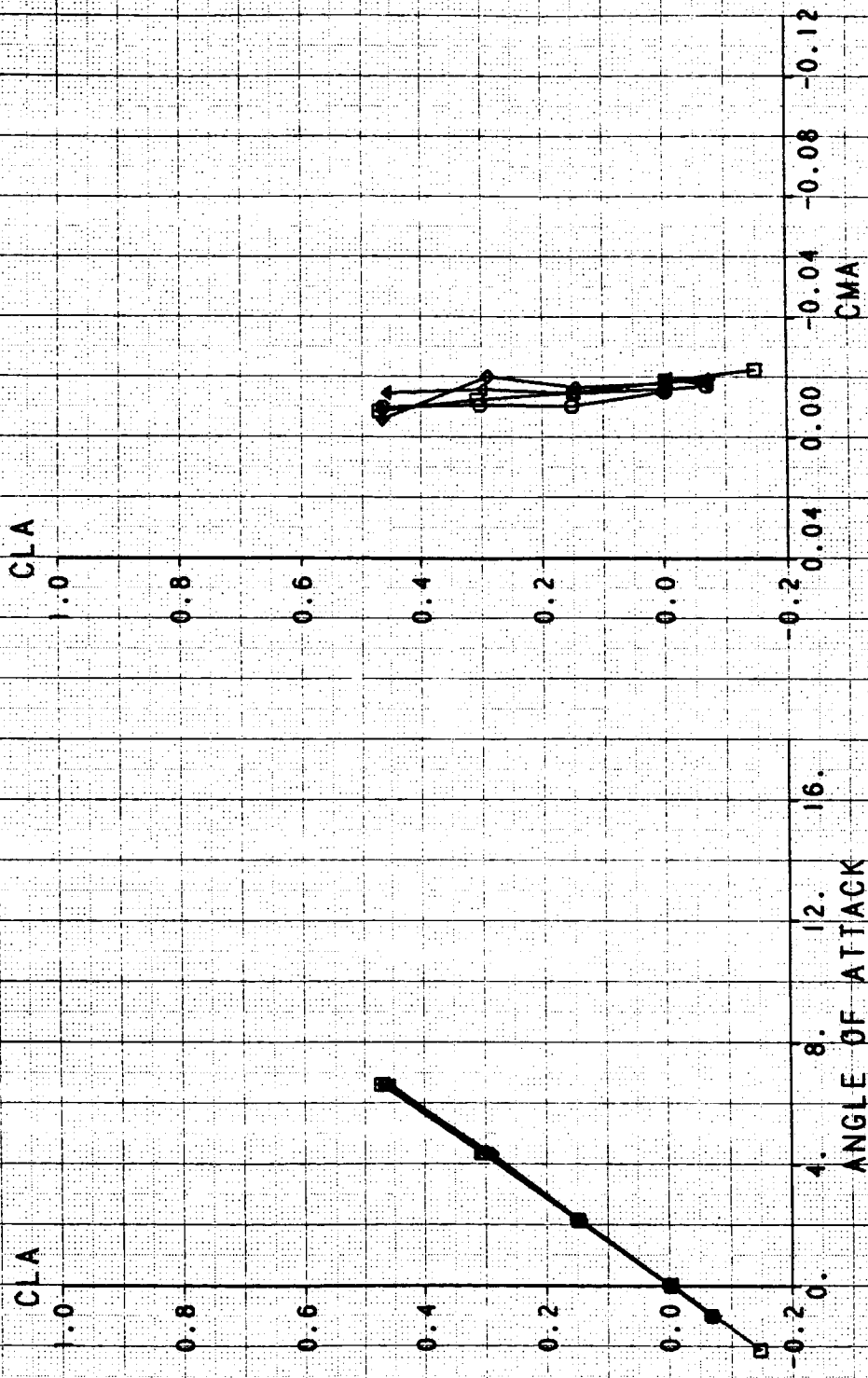JET-EFFECTS MODE WITH UNVECTORED A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
□	514	238	0.3989	0.0637	-4.9629
△	514	258	0.3992	4.0334	-5.0064

110

NOZZLE PRESSURE RATIO EFFECT ON CL VS AOA AND CM
JET-EFFECTS MODE WITH UNVECTORED A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
▫	514	238	0.3989	0.0637	-4.9629
▲	514	258	0.3992	4.0334	-5.0064

CL

CM

CL

ANGLE OF ATTACK

NOZZLE PRESSURE RATIO EFFECT ON DRAG POLAR
JET-EFFECTS MODE WITH UNVECTORED A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
▢	514	243	0.6214	0.0906	-4.9911
▲	514	259	0.6009	4.1998	-4.9763

112

NOZZLE PRESSURE RATIO EFFECT ON CL VS AOA AND CM
JET-EFFECTS MODE WITH UNVECTORED A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
□	514	243	0.6214	0.0906	-4.9911
▲	514	259	0.6009	4.1998	-4.9763

ANGLE OF ATTACK

CM

CL

NOZZLE PRESSURE RATIO EFFECT ON DRAG POLAR
JET-EFFECTS MODE WITH UNVECTORED A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
☐	514	244	0.9022	0.1384	-4.9674
▲	514	262	0.9019	6.0982	-4.9891

114

NOZZLE PRESSURE RATIO EFFECT ON CL VS AOA AND CM
JET-EFFECTS MODE WITH UNVECTORED A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
□	514	244	0.9022	0.1384	-4.9674
▲	514	262	0.9019	6.0982	-4.9891

CM

ANGLE OF ATTACK

CL

115

NOZZLE PRESSURE RATIO EFFECT ON DRAG POLAR
JET-EFFECTS MODE WITH UNVECTORED A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
□	514	245	1.1772	0.1893	-0.1056
▲	514	252	1.1940	9.0806	-0.0448

116

NOZZLE PRESSURE RATIO EFFECT ON CL VS AOA AND CM
JET-EFFECTS MODE WITH UNVECTORED A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
▢	514	245	1.1772	0.1893	-0.1056
▲	514	252	1.1940	9.0806	-0.0448

117

NOZZLE PRESSURE RATIO EFFECT ON DRAG POLAR
JET-EFFECTS MODE WITH UNVECTORED A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
□	514	246	1.3548	0.2345	.00883
▲	514	254	1.3859	10.389	-0.0460

118

NOZZLE PRESSURE RATIO EFFECT ON CL VS AOA AND CM
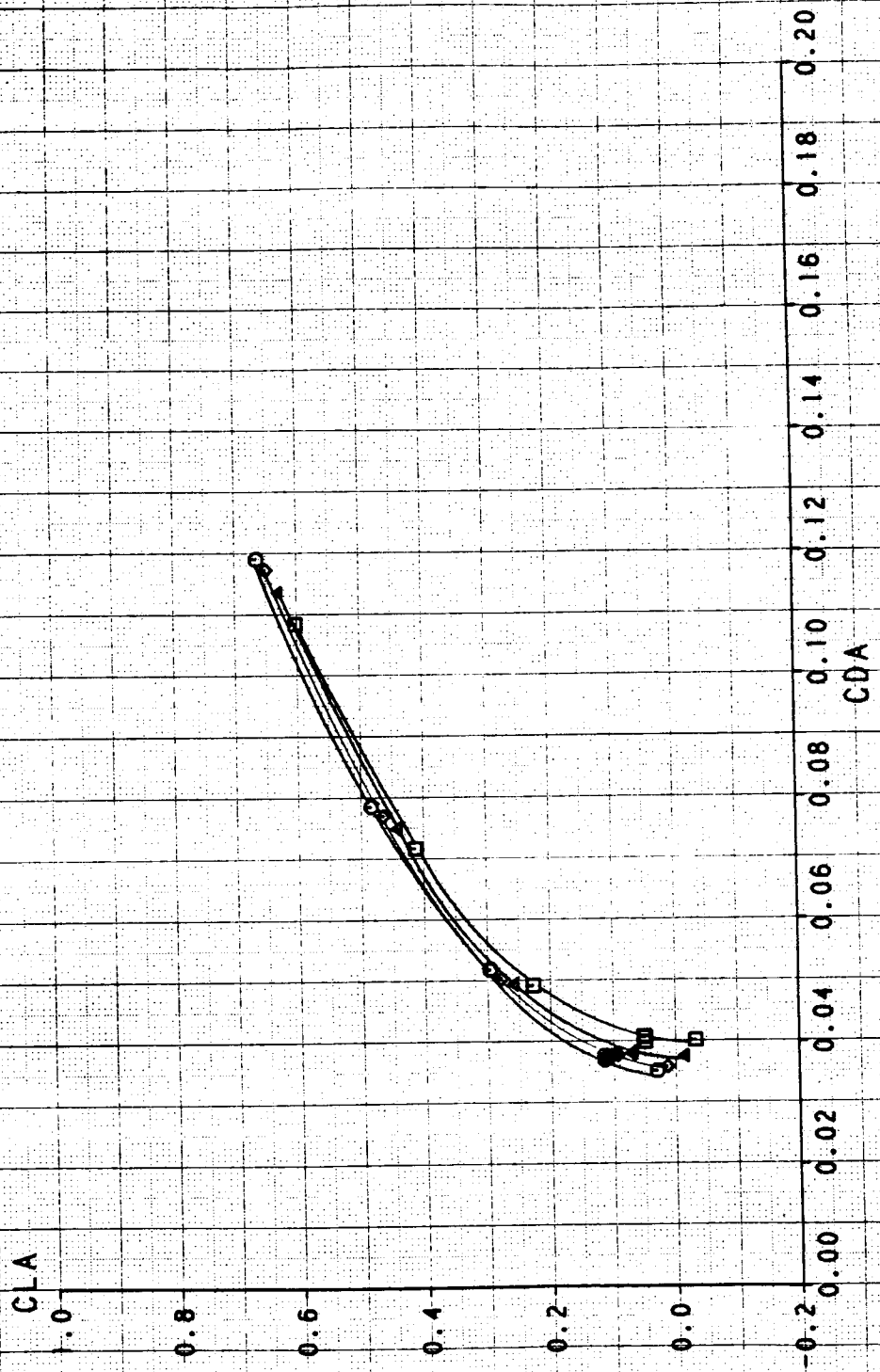JET-EFFECTS MODE WITH UNVECTORED A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
⊡	514	246	1.3548	0.2345	.00883
▲	514	254	1.3859	10.389	-0.0460

CL

ANGLE OF ATTACK

CM

119

NOZZLE PRESSURE RATIO EFFECT ON DRAG POLAR
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RMFR	RDELCL
□	514	283	0.4017	1.6483	1.1604	-5.0039
△	514	284	0.4014	1.9882	1.1603	-5.0028
◇	514	285	0.4019	2.4178	1.1571	-4.9983
⊖	514	288	0.4032	3.3566	1.1353	-5.0263

NOZZLE PRESSURE RATIO EFFECT ON CL VS AOA AND CM
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RMFR	RDELCL
□	514	283	0.4017	1.6483	1.1604	-5.0039
△	514	284	0.4014	1.9882	1.1603	-5.0028
◇	514	285	0.4019	2.4178	1.1571	-4.9983
○	514	288	0.4032	3.3566	1.1353	-5.0263

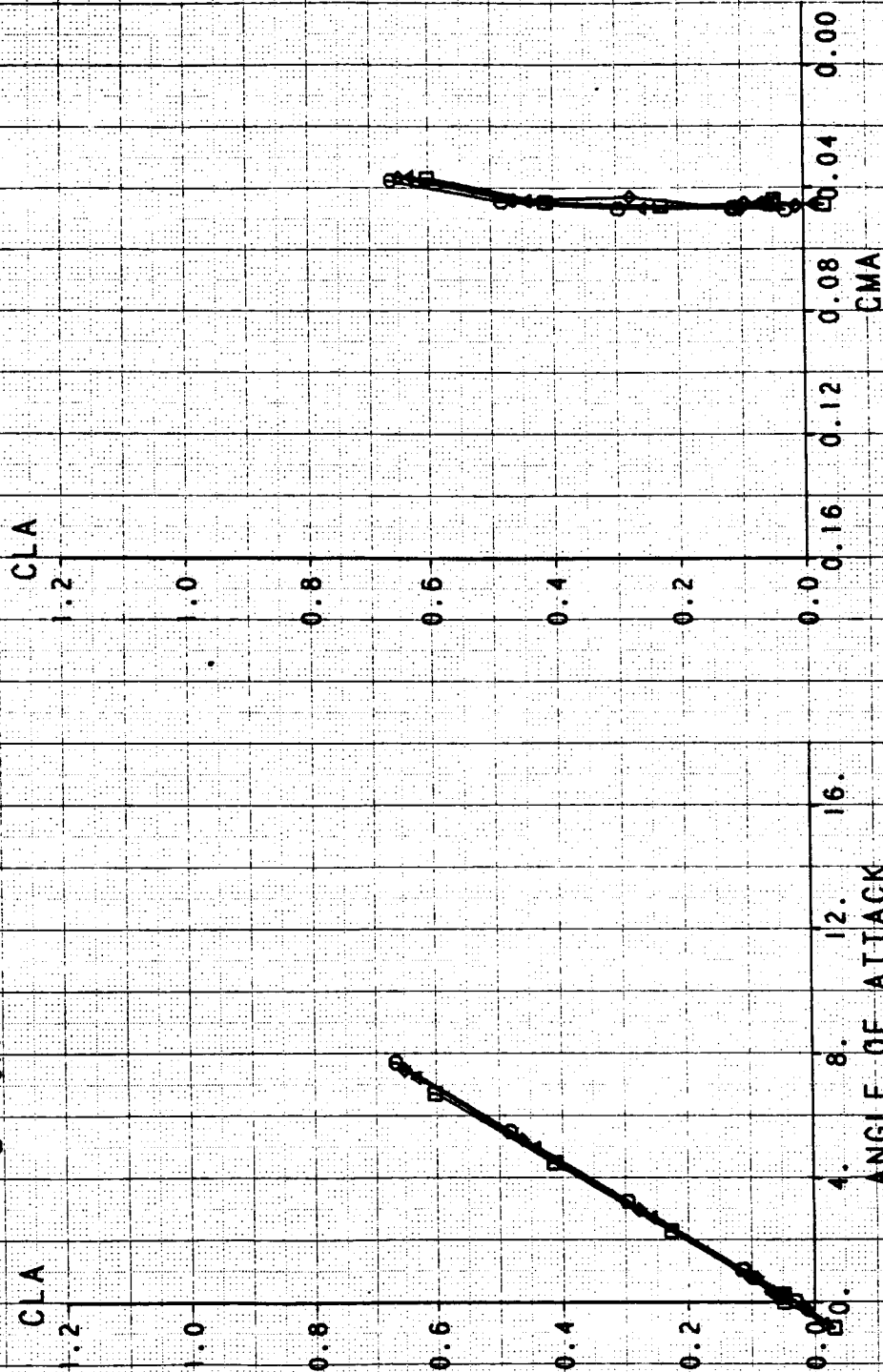NOZZLE PRESSURE RATIO EFFECT ON DRAG POLAR
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RMFR	RDELCL
□	514	175	0.5992	3.2903	0.9202	0.1480
▲	514	178	0.6009	3.8301	0.9161	0.1001

NOZZLE PRESSURE RATIO EFFECT ON CL VS AOA AND CM
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RMFR	RDELCL
□	514	175	0.5992	3.2903	0.9202	0.1480
▲	514	178	0.6009	3.8301	0.9161	0.1001

CM

CL

ANGLE OF ATTACK

CL

NOZZLE PRESSURE RATIO EFFECT ON DRAG POLAR
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RMFR	RDELCL
□	514	211	0.8966	2.4771	0.7627	-4.9703
△	514	213	0.8953	3.6541	0.7639	-4.9849
◇	514	214	0.8987	4.3555	0.7595	-4.9849
⊕	514	215	0.8964	5.3011	0.7534	-4.9625

CL

CD

-0.2 0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14 0.16 0.18 0.20

1.0 0.8 0.6 0.4 0.2 0.0 -0.2

NOZZLE PRESSURE RATIO EFFECT ON CL VS AOA AND CM
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RMFR	RDELCL
□	514	211	0.8966	2.4771	0.7627	-4.9703
△	514	213	0.8953	3.6541	0.7639	-4.9849
◇	514	214	0.8987	4.3555	0.7595	-4.9849
◯	514	215	0.8964	5.3011	0.7534	-4.9625

125

NOZZLE PRESSURE RATIO EFFECT ON DRAG POLAR
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RMFR	RDELCL
□	514	239	1.1834	4.2464	0.6863	0.1042
▲	514	240	1.1896	5.2134	0.6841	0.1043
◇	514	241	1.1903	6.1521	0.6803	0.1125
⊖	514	242	1.1906	7.5840	0.7579	0.1042

126

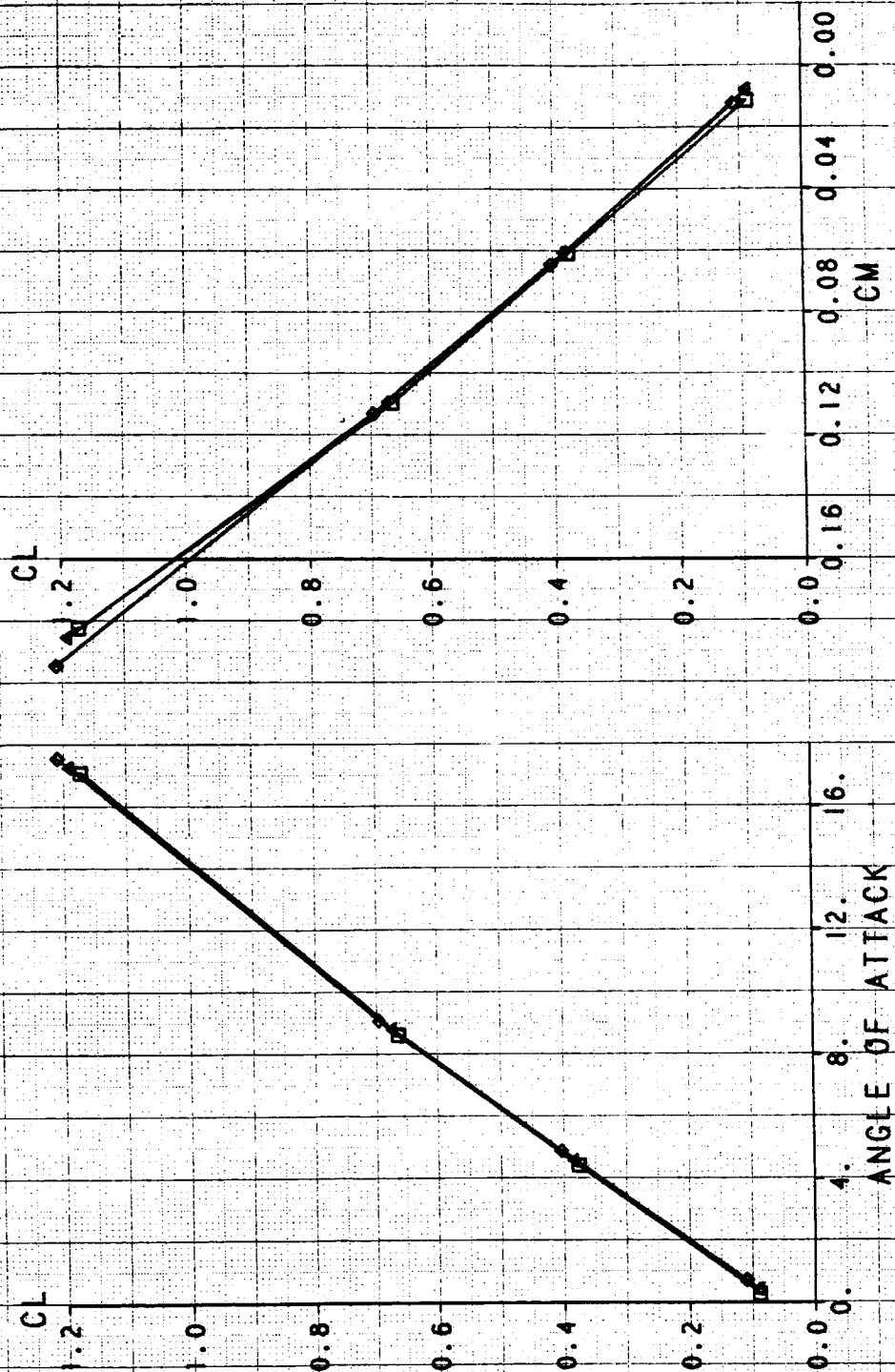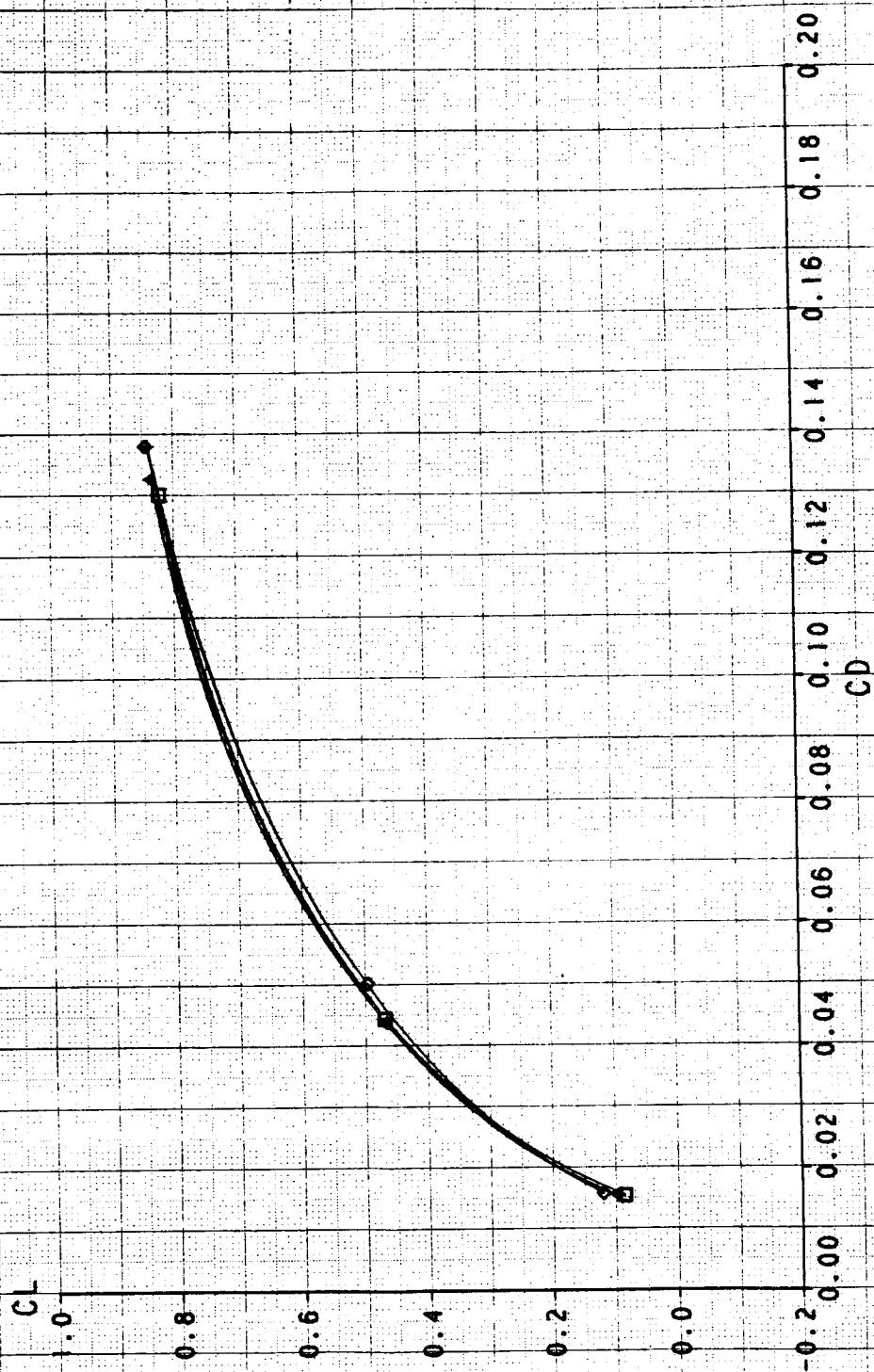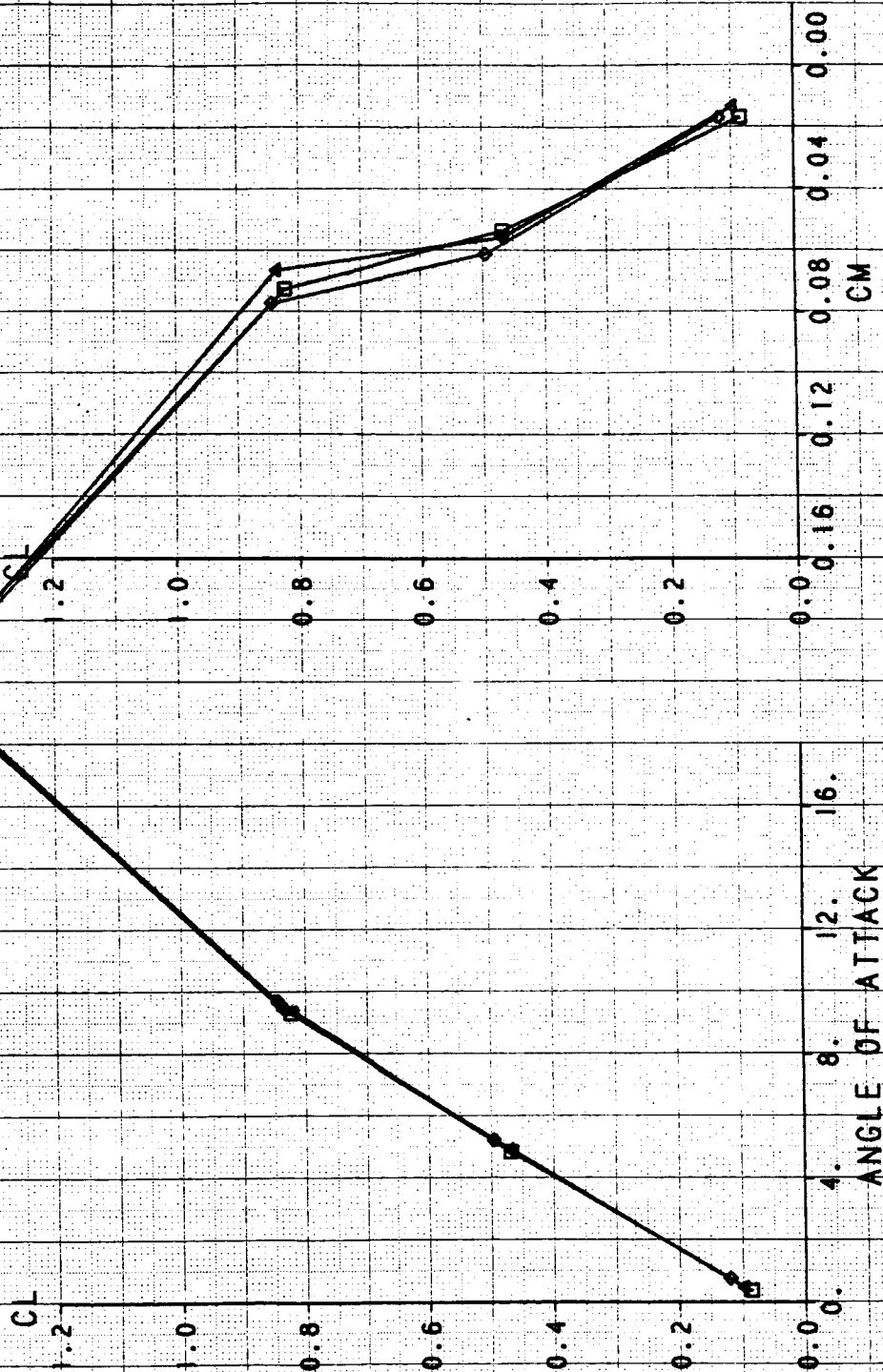NOZZLE PRESSURE RATIO EFFECT ON CL VS AOA AND CM
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RMFR	RDELCL
□	514	239	1.1834	4.2464	0.6863	0.1042
△	514	240	1.1896	5.2134	0.6841	0.1083
◇	514	241	1.1903	6.1521	0.6803	0.1125
⊙	514	242	1.1906	7.5840	0.7579	0.1042

NOZZLE PRESSURE RATIO EFFECT ON DRAG POLAR
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RMFR	RDELCL
□	514	253	1.3958	5.4634	0.7198	0.1281
▲	514	254	1.3978	6.6757	0.7203	0.1229
◇	514	255	1.3966	7.8725	0.7118	0.1322
⊕	514	256	1.3969	9.5970	0.7929	0.1083

CL

CD

NOZZLE PRESSURE RATIO EFFECT ON CL VS AOA AND CM
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RMFR	RDELCL
☐	514	253	1.3958	5.4634	0.7198	0.1281
△	514	254	1.3978	6.6757	0.7203	0.1229
◇	514	255	1.3966	7.8725	0.7118	0.1322
◯	514	256	1.3969	9.5970	0.7929	0.1083

CL

CM

ANGLE OF ATTACK

NOZZLE PRESSURE RATIO EFFECTS ON DRAG POLAR
JET-EFFECTS MODE WITH A/B ALBEN VECTORING THRUST 20 DEG

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
□	514	273	0.4006	0.5460	-4.9263
▲	514	271	0.3987	4.0129	-4.9364

NOZZLE PRESSURE RATIO EFFECT ON CL VS AOA AND CM
JET-EFFECTS MODE WITH A/B ALBEN VECTORING THRUST 20 DEG

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
☐	514	273	0.4006	0.5460	-4.9263
▲	514	271	0.3987	4.0129	-4.9364

JET-EFFECTS NOZZLE PRESSURE RATIO EFFECTS ON DRAG POLAR
EFFECTS MODE WITH A/B ALBEN VECTORING THRUST 20 DEG

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
□	514	268	0.6006	0.0857	-5.0006
▲	514	270	0.5991	4.2228	-4.9460

NOZZLE PRESSURE RATIO EFFECT ON CL VS AOA AND CM
JET-EFFECTS MODE WITH A/B ALBEN VECTORING THRUST 20 DEG

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
⊡	514	268	0.6006	0.0857	-5.0006
▲	514	270	0.5991	4.2228	-4.9460

JET-EFFECTS   NOZZLE PRESSURE RATIO EFFECTS ON DRAG POLAR
               MODE WITH A/B ALBEN VECTORING THRUST 20 DEG

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
□	514	265	0.9002	0.1164	-5.1428
▲	514	267	0.9020	6.1170	-5.0041

134

NOZZLE PRESSURE RATIO EFFECT ON CL VS AOA AND CM
JET-EFFECTS MODE WITH A/B ALBEN VECTORING THRUST 20 DEG

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
☐	514	265	0.9002	0.1164	-5.1428
▲	514	267	0.9020	6.1170	-5.0041

135

JET-EFFECTS NOZZLE PRESSURE RATIO EFFECTS ON DRAG POLAR
EFFECTS MODE WITH A/B ALBEN VECTORING THRUST 20 DEG

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
□	514	284	1.2014	0.1782	-0.0584
▲	514	282	1.1956	8.9103	-0.0392

136
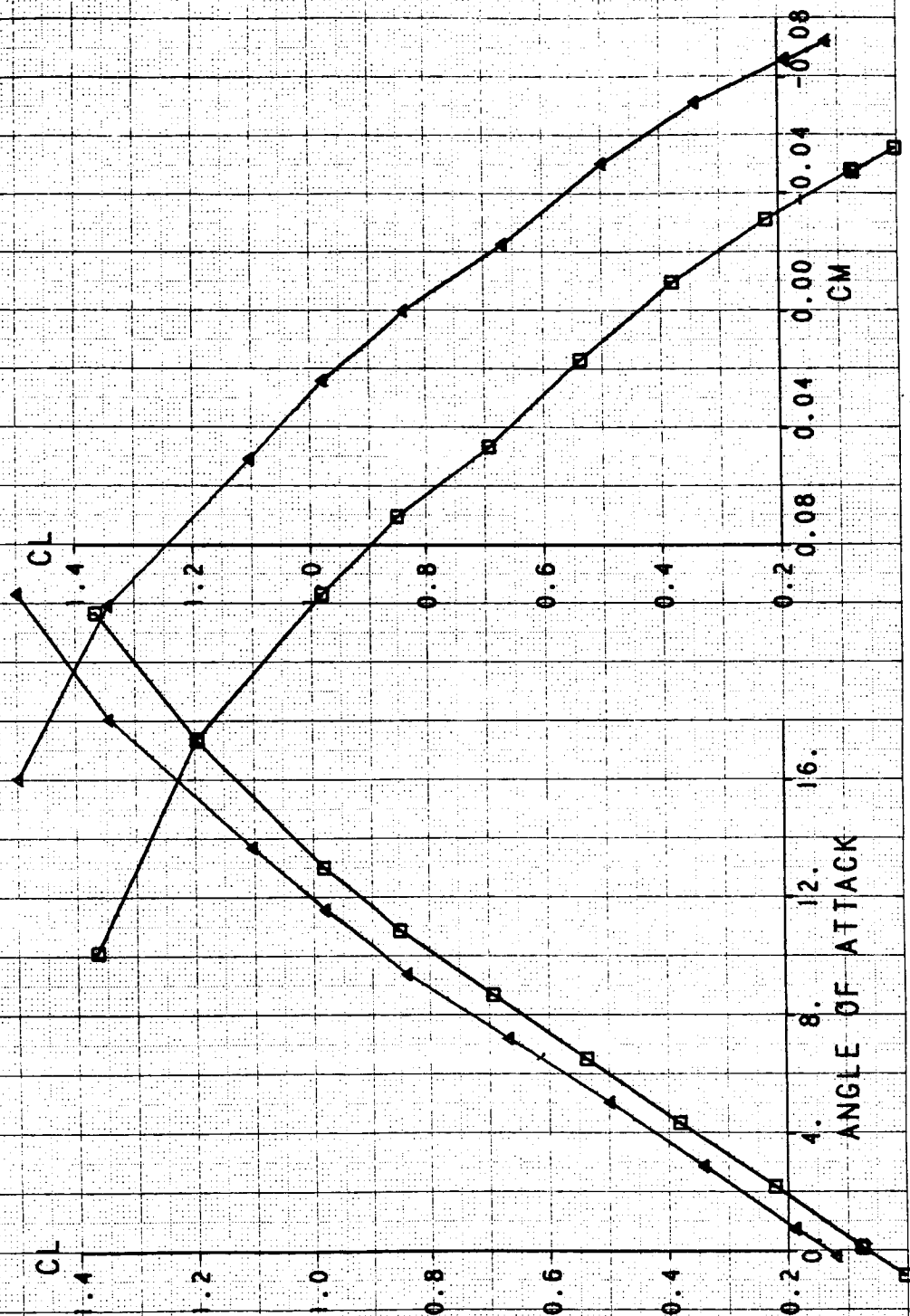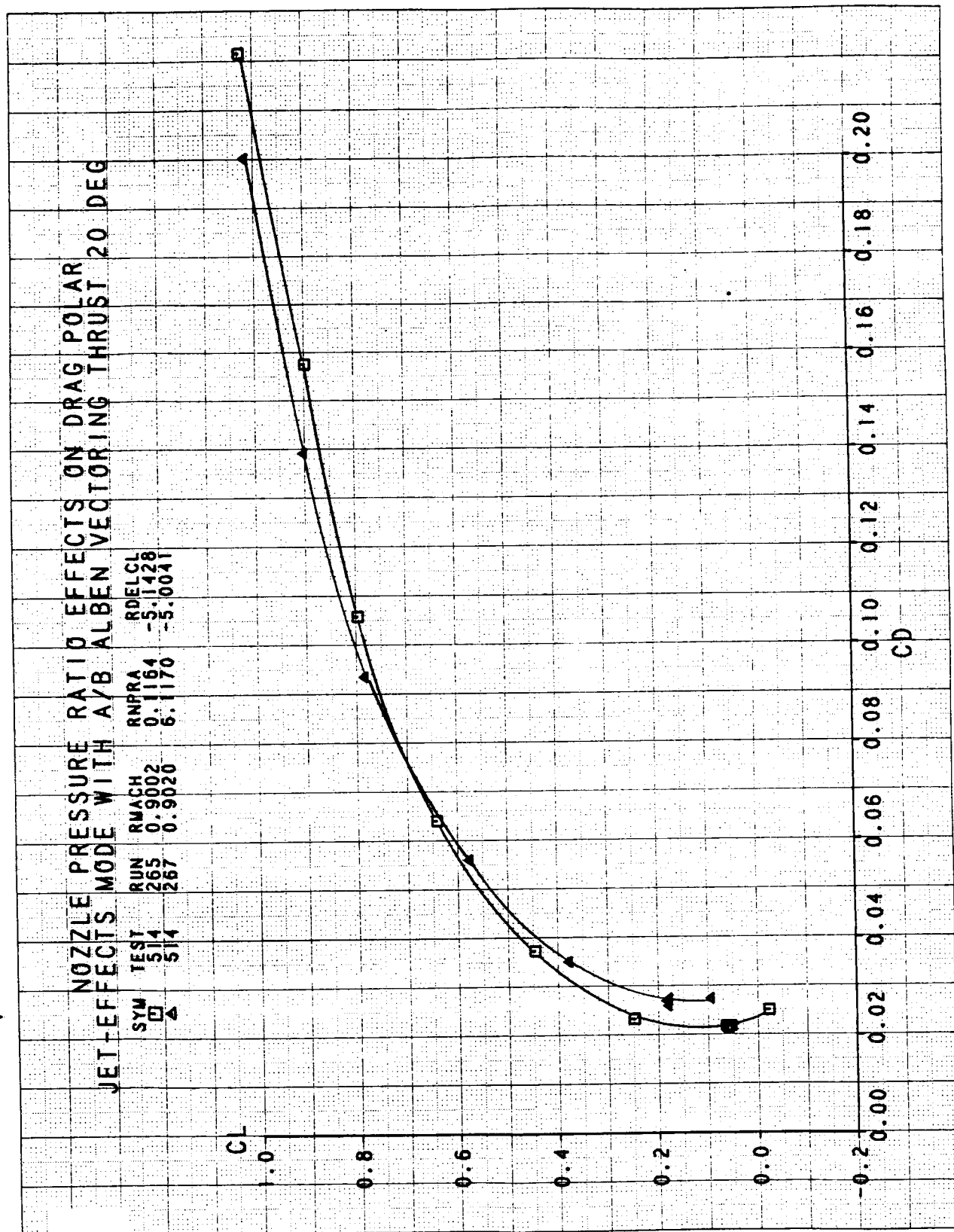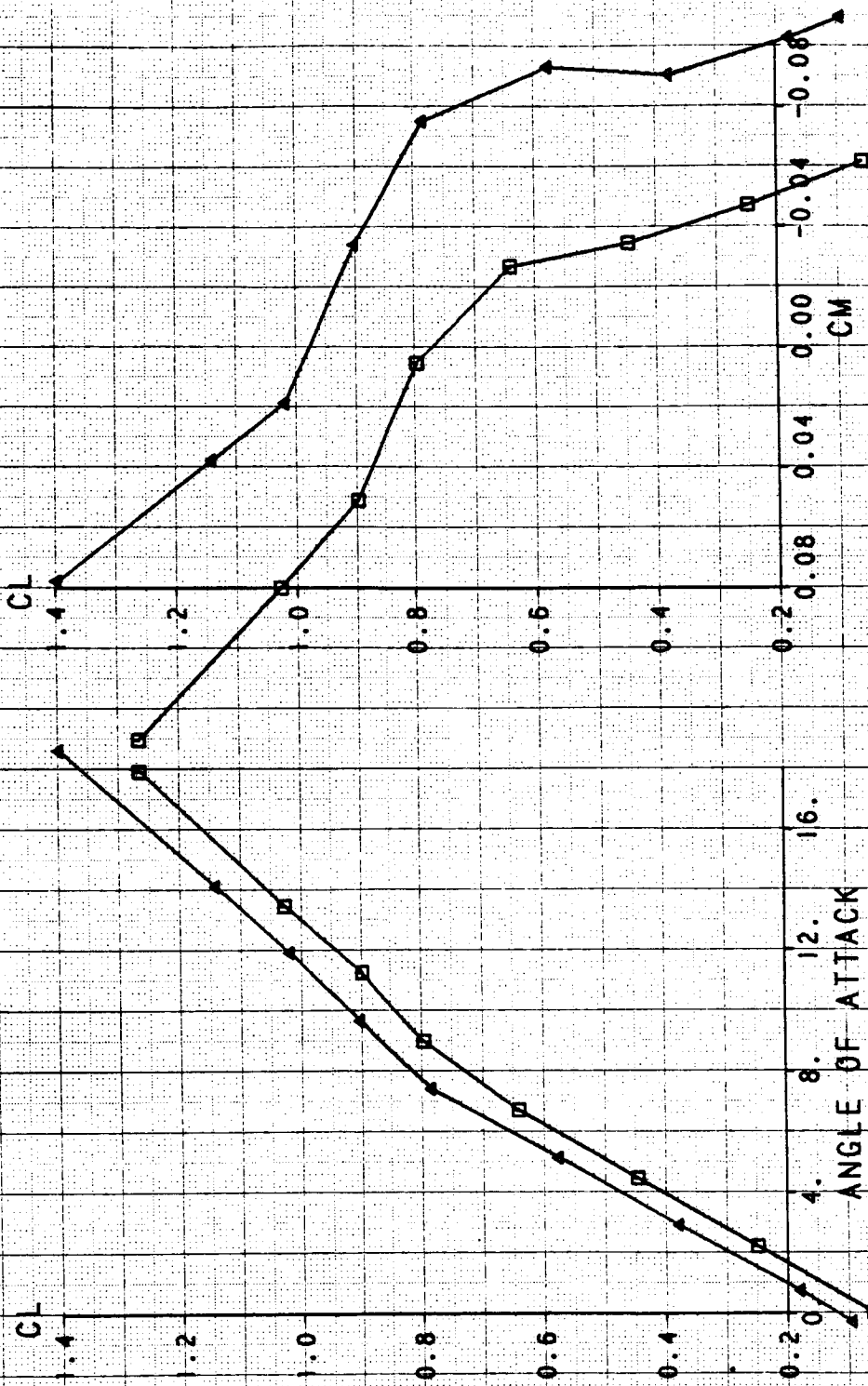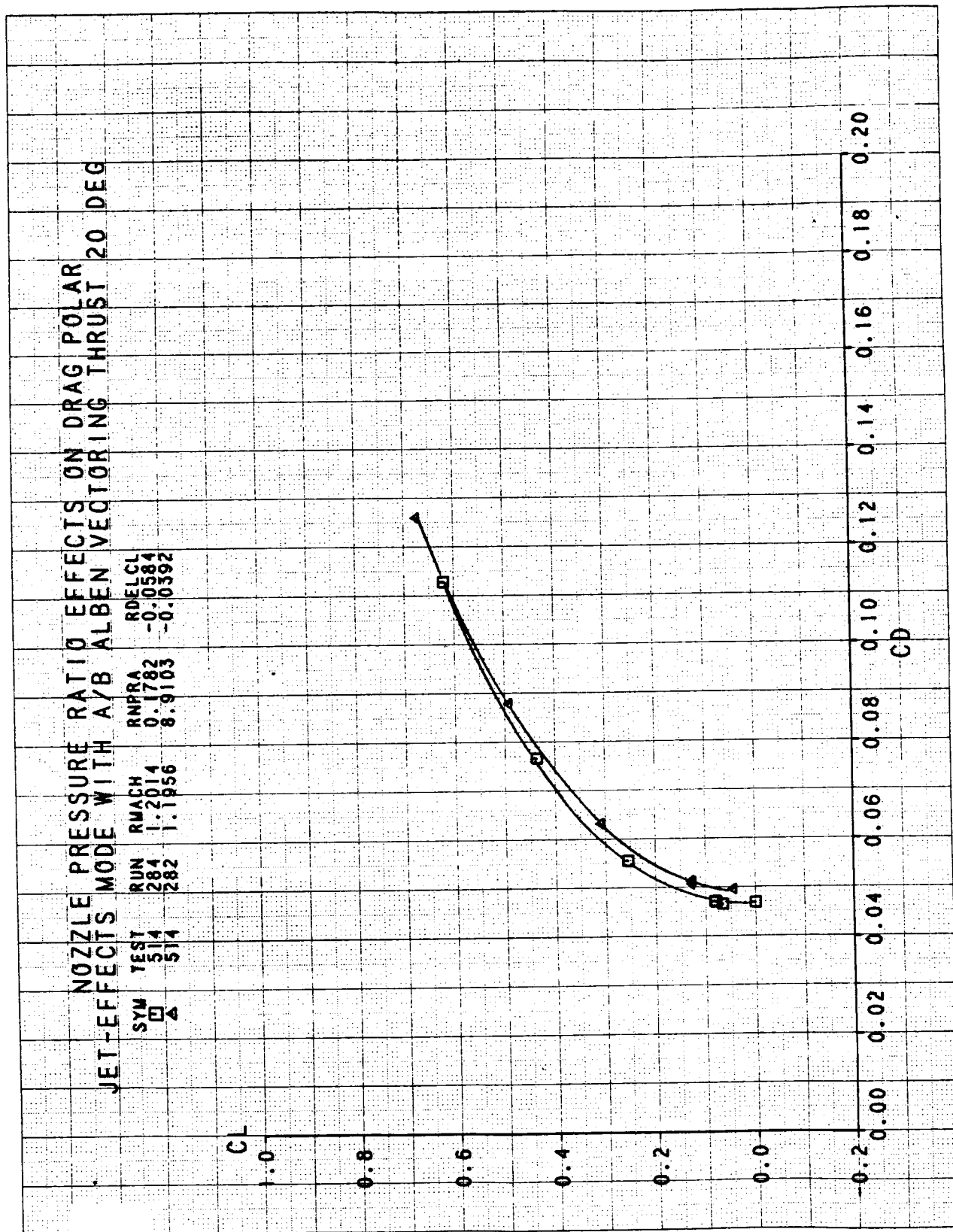
NOZZLE PRESSURE RATIO EFFECT ON CL VS AOA AND CM
JET-EFFECTS MODE WITH A/B ALBEN VECTORING THRUST 20 DEG

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
□	514	284	1.2014	0.1782	-0.0584
△	514	282	1.1956	8.9103	-0.0392

NOZZLE PRESSURE RATIO EFFECT ON DRAG POLAR
JE MODE WITH A/B ALBEN VECTORED 30 DEG AND WING FLAP 30 DEG

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
□	514	299	0.3990	0.0581	-4.9894
▲	514	293	0.4002	3.2664	-5.0077

138

NOZZLE PRESSURE RATIO EFFECT ON CL VS AOA AND CM
JE MODE WITH A/B ALBEN VECTORED 30 DEG AND WING FLAP 30 DEG

SYM	TEST	RUN	RMACH	RNPRA	RDELCL
□	514	299	0.3990	0.0581	-4.9894
▲	514	298	0.4002	3.2664	-5.0077

139

THRUST VECTORING EFFECT ON DRAG POLAR
JET-EFFECTS MODE WITH A/B ALBEN
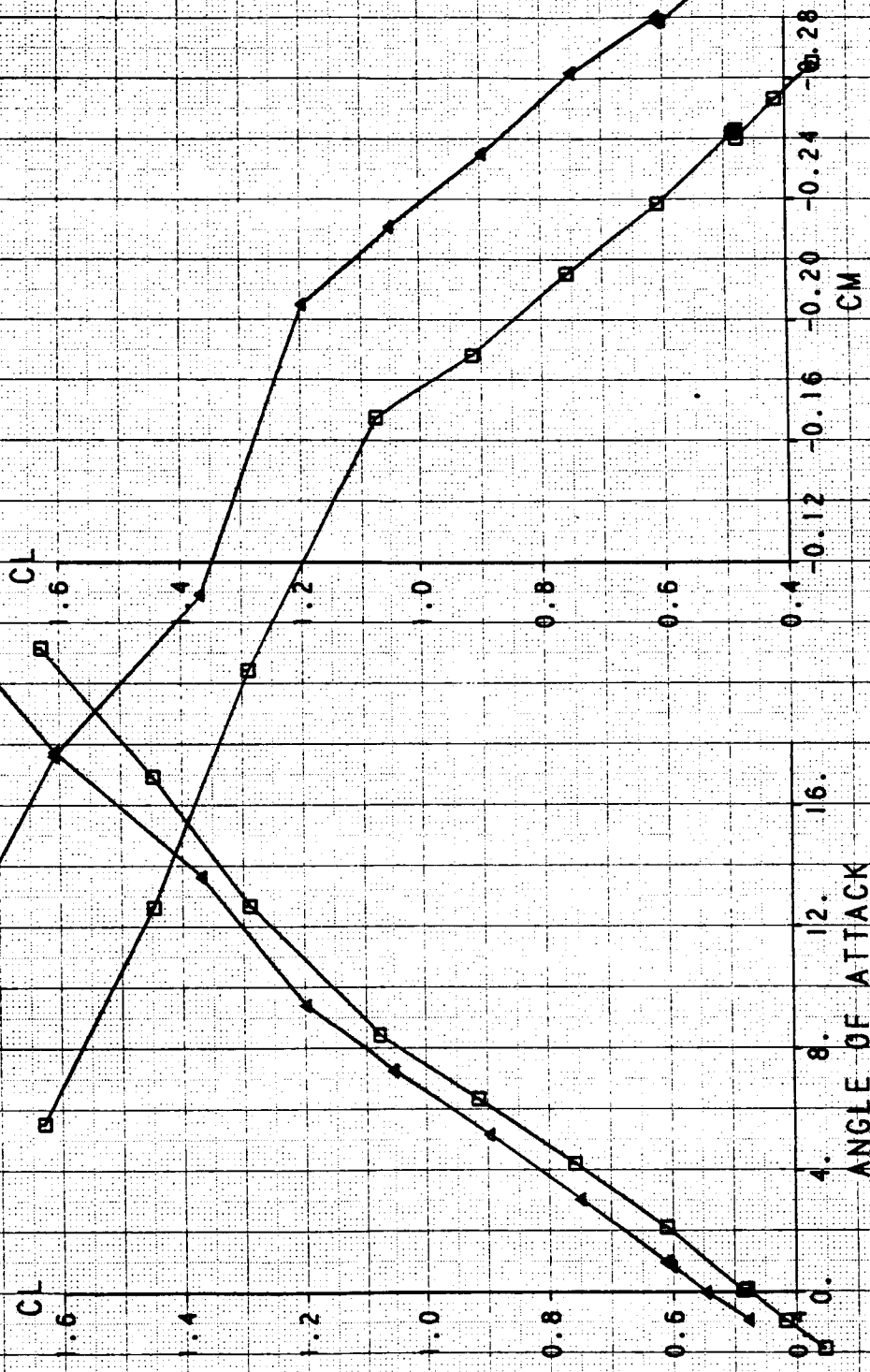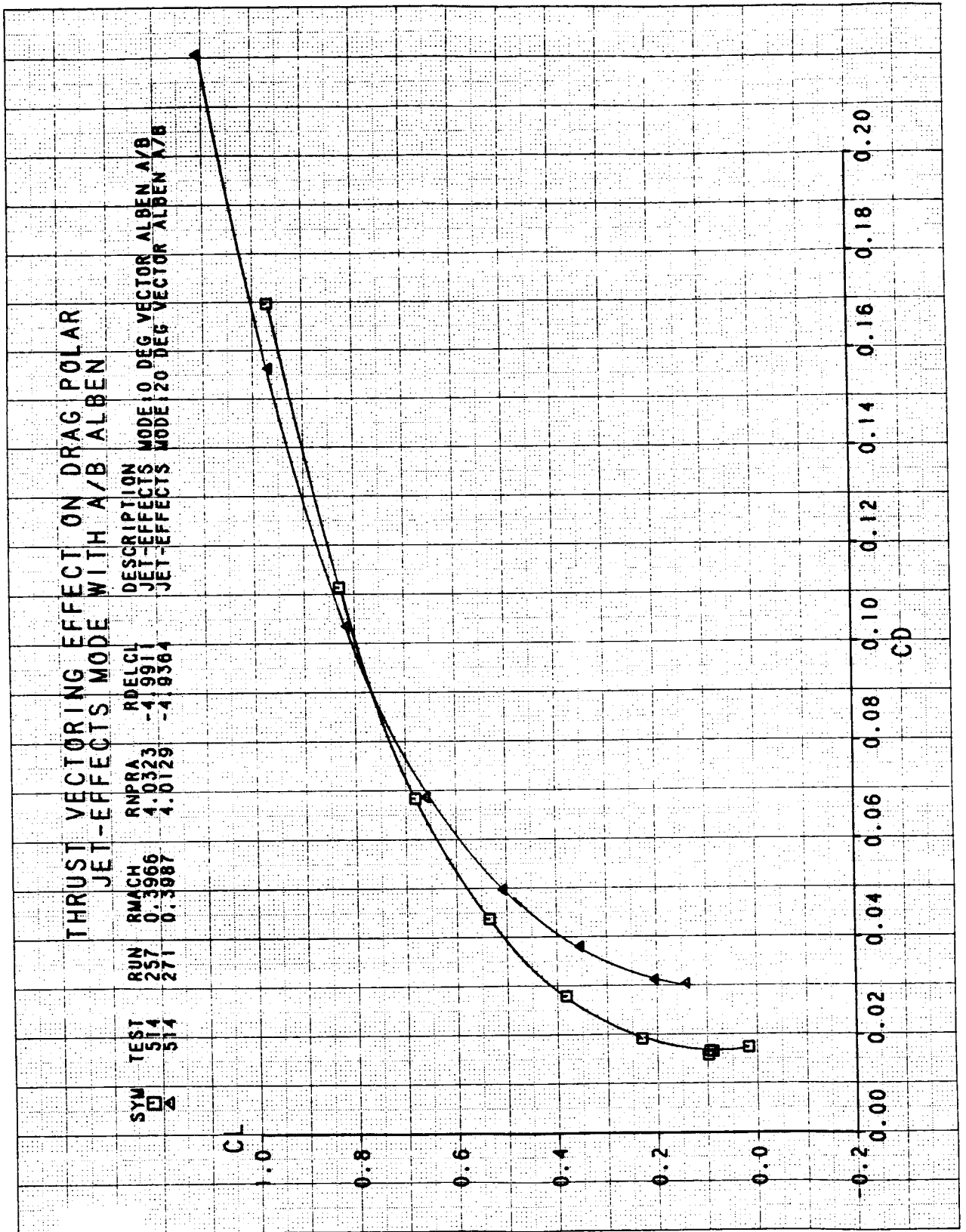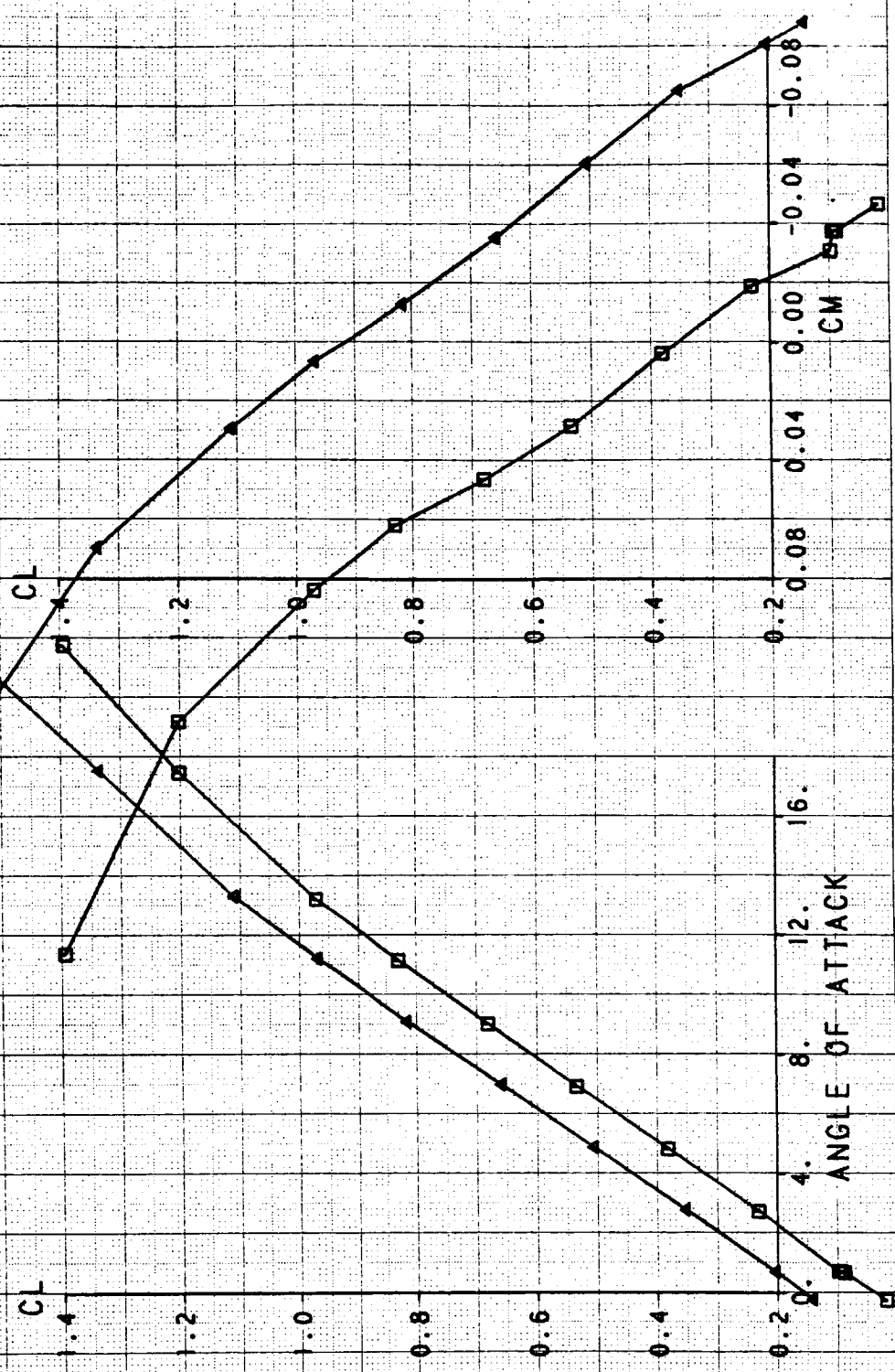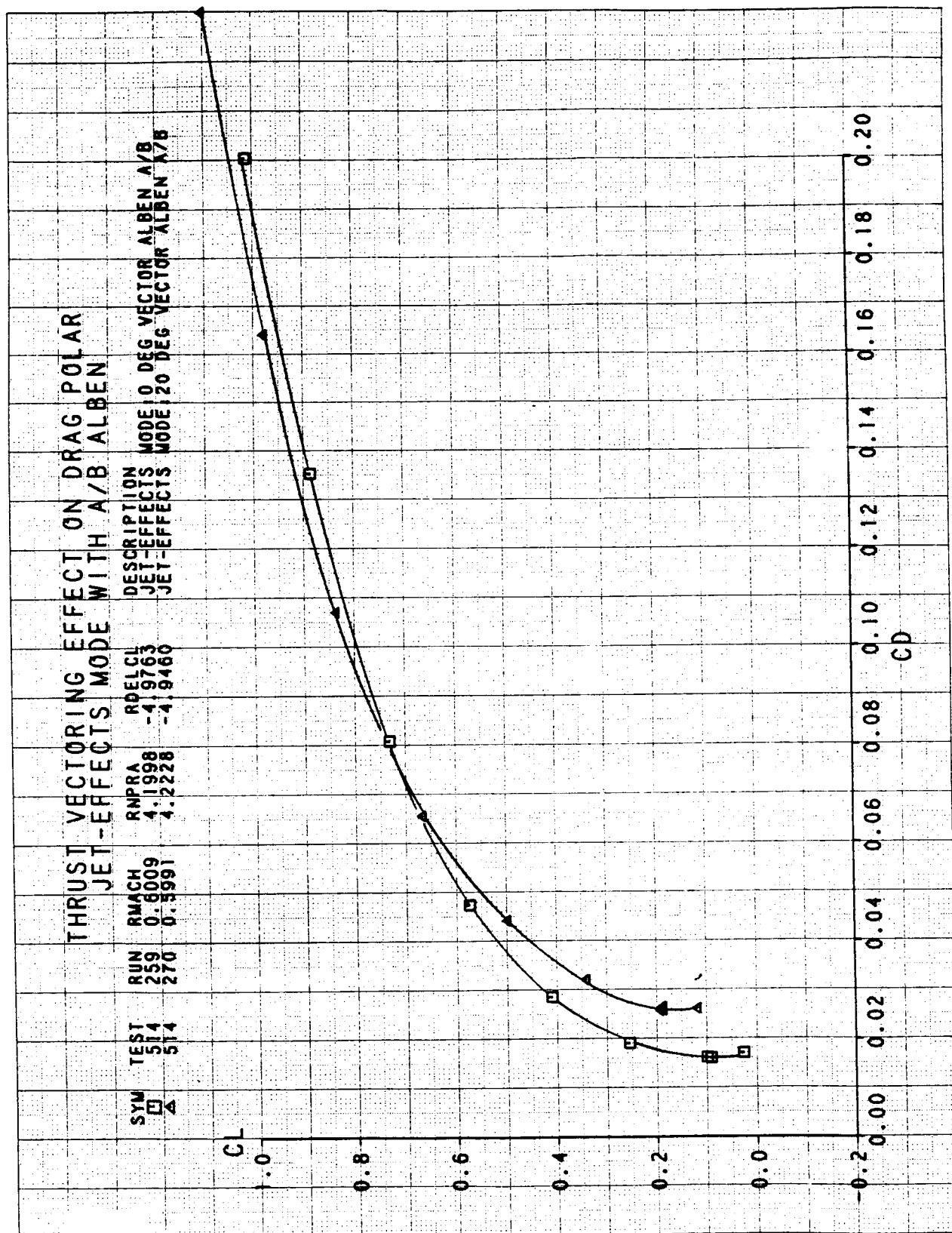
SYM	TEST	RUN	RMACH	RNPRA	RDELCL	DESCRIPTION
▣	514	257	0.3966	4.0323	-4.9911	JET-EFFECTS MODE:0 DEG VECTOR ALBEN A/B
△	514	271	0.3987	4.0129	-4.9364	JET-EFFECTS MODE:20 DEG VECTOR ALBEN A/B

THRUST VECTORING EFFECT ON CL VS AOA AND CM
JET-EFFECTS MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL	DESCRIPTION
▢	514	257	0.3966	4.0323	.9911	JET-EFFECTS MODE 10 DEG VECTOR ALBEN A/B
▲	514	271	0.3987	4.0129	-4.9364	JET-EFFECTS MODE 20 DEG VECTOR ALBEN A/B

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THRUST VECTORING EFFECT ON DRAG POLAR
JET-EFFECTS MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL	DESCRIPTION
☐	514	259	0.6009	4.1998	-4.9763	JET-EFFECTS MODE;0 DEG VECTOR ALBEN A/B
△	514	270	0.5991	4.2228	-4.9460	JET-EFFECTS MODE;20 DEG VECTOR ALBEN X7B

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THRUST VETCTORING EFFECT ON CL VS AOA AND CM
JET-EFFECTS MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL	DESCRIPTION
□	514	259	0.6009	4.1998	-4.9763	JET-EFFECTS MODE:0 DEG VECTOR ALBEN A/B
△	514	270	0.5991	4.2228	-4.9460	JET-EFFECTS MODE:20 DEG VECTOR ALBEN A/B

143

THRUST VECTORING EFFECT ON DRAG POLAR
JET-EFFECTS MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL	DESCRIPTION
□	514	250	0.8999	6.2195	-4.9737	JET-EFFECTS MODE 0 DEG VECTOR ALBEN A/B
△	514	280	0.9001	6.2122	-4.9963	JET-EFFECTS MODE 20 DEG VECTOR ALBEN A/B

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THRUST VETCTORING EFFECT ON CL VS AOA AND CM
JET-EFFECTS MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL	DESCRIPTION		
▢	514	250	0.8999	6.2195	-4.9737	JET-EFFECTS	MODE:0 DEG	VECTOR ALBEN A/B
▲	514	280	0.9001	6.2122	-4.9963	JET-EFFECTS	MODE:20 DEG	VECTOR ALBEN A/B

ANGLE OF ATTACK

145
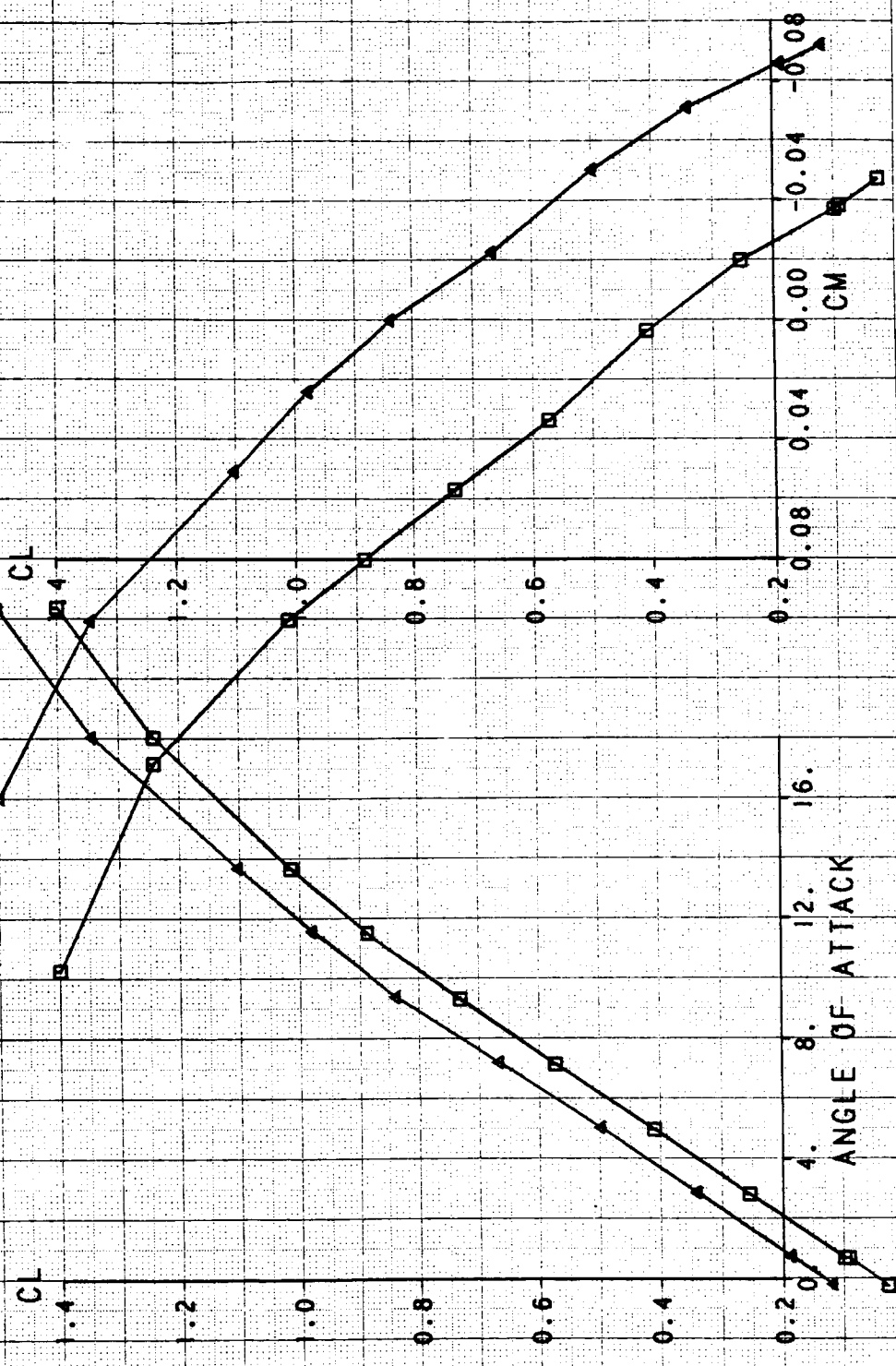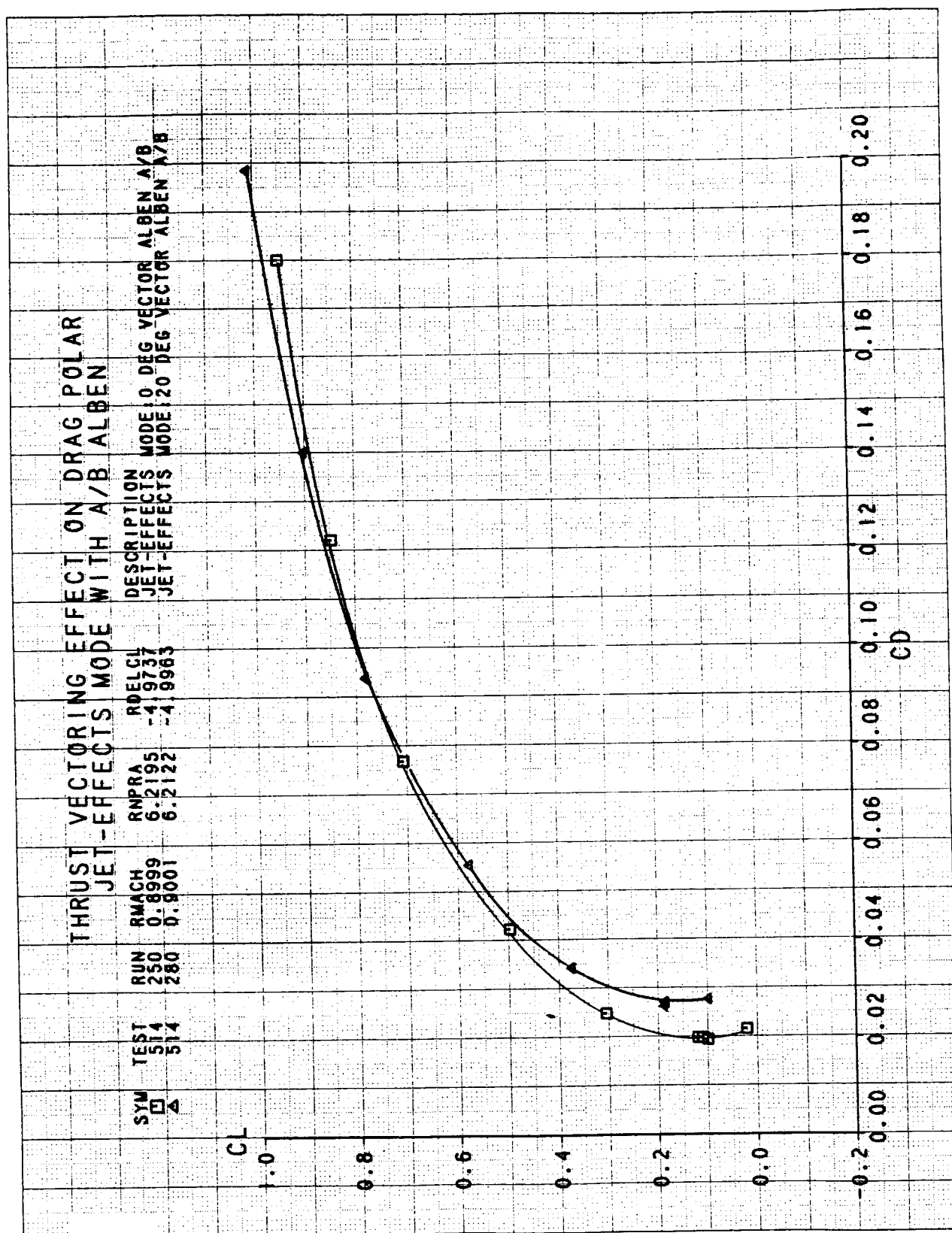
WING FLAP ROTATION AND THRUST VECTORING EFFECT ON DRAG POLAR
JET-EFFECTS MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELGL	DESCRIPTION
☐	514	257	0.3966	4.0323	-4.9911	JET-EFFECTS MODE 0 DEG VECTOR ALBEN A/B 0° WING FLAP
△	514	287	0.4002	4.0869	-4.9928	JET-EFFECTS MODE 30 DEG VECTOR ALBEN A/B 30° WING FLAP

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WING FLAP ROTATION AND THRUST VECTORING EFFECT ON CL VS AOA & CM
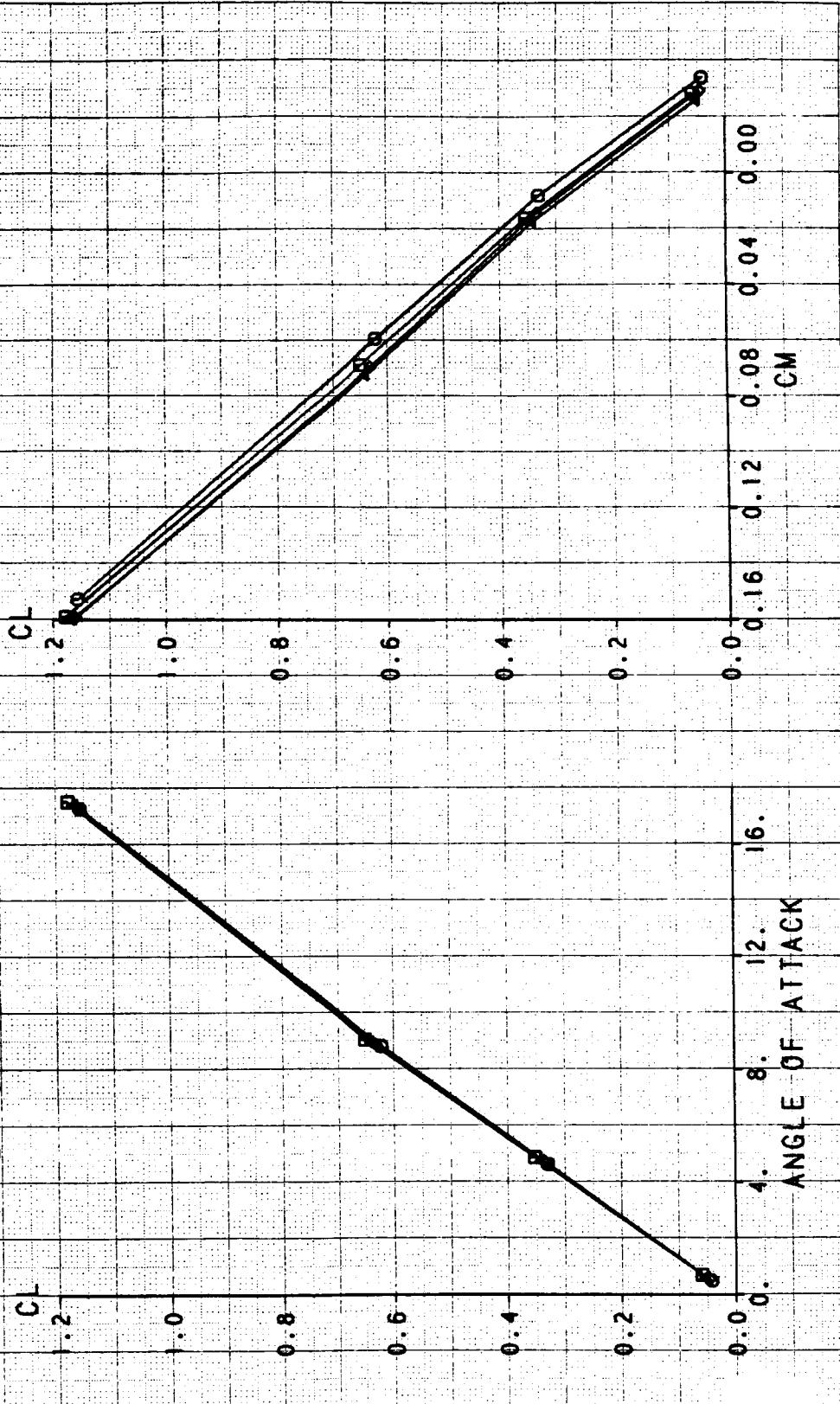JET-EFFECTS MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL	DESCRIPTION
□	514	257	0.3966	4.0323	-.9911	JET-EFFECTS MODE;0 DEG VECTOR ALBEN A/B, 0° WING FLAP
△	514	287	0.4002	4.0869	.9928	JET-EFFECTS MODE;30 DEG VECTOR ALBEN A/B, 30° WING FLAP

147

POWER SETTING EFFECT ON DRAG POLAR
JET-EFFECTS MODE WITH ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL	DESCRIPTION
□	514	259	0.6009	4.1998	-4.9763	JET-EFFECTS MODE;0 DEG VECTOR ALBEN A/B
△	514	314	0.6001	4.6697	-4.9617	JET-EFFECTS MODE;0 DEG VECTOR ALBEN DRY

148

POWER SETTING EFFECT ON CL VS AOA AND CM
JET-EFFECTS MODE WITH ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL	DESCRIPTION
□	514	259	0.6009	4.1998	-4.9763	JET-EFFECTS MODE:0 DEG VECTOR ALBEN A/B
△	514	314	0.6001	4.8607	-4.9617	JET-EFFECTS MODE:0 DEG VECTOR ALBEN DRY

ANGLE OF ATTACK

149

POWER SETTING EFFECT ON DRAG POLAR
JET-EFFECTS MODE WITH ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL	DESCRIPTION
□	514	250	0.8999	6.2195	-4.9737	JET-EFFECTS MODE:0 DEG VECTOR ALBEN A/B
△	514	315	0.8992	6.7075	-4.9260	JET-EFFECTS MODE:0 DEG VECTOR ALBEN DRY

POWER SETTING EFFECT ON CL VS AOA AND CM
JET-EFFECT MODE WITH ALBEN

SYM	TEST	RUN	RMACH	RNPRA	RDELCL	DESCRIPTION
☐	514	250	0.8999	6.2195	-4.9737	JET-EFFECTS MODE 10 DEG VECTOR ALBEN A/B
△	514	315	0.8992	6.7075	-4.9260	JET-EFFECTS MODE 10 DEG VECTOR ALBEN DRY

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CANARD ROTATION EFFECTS ON CLA VS CDA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
□	514	164	0.3996	1.1079	5.0449
▲	514	165	0.3989	1.2024	-0.0455
◇	514	167	0.4016	1.1343	-4.9956
◯	514	168	0.3985	1.2163	-10.002
✳	514	169	0.3983	1.2087	-15.008

152
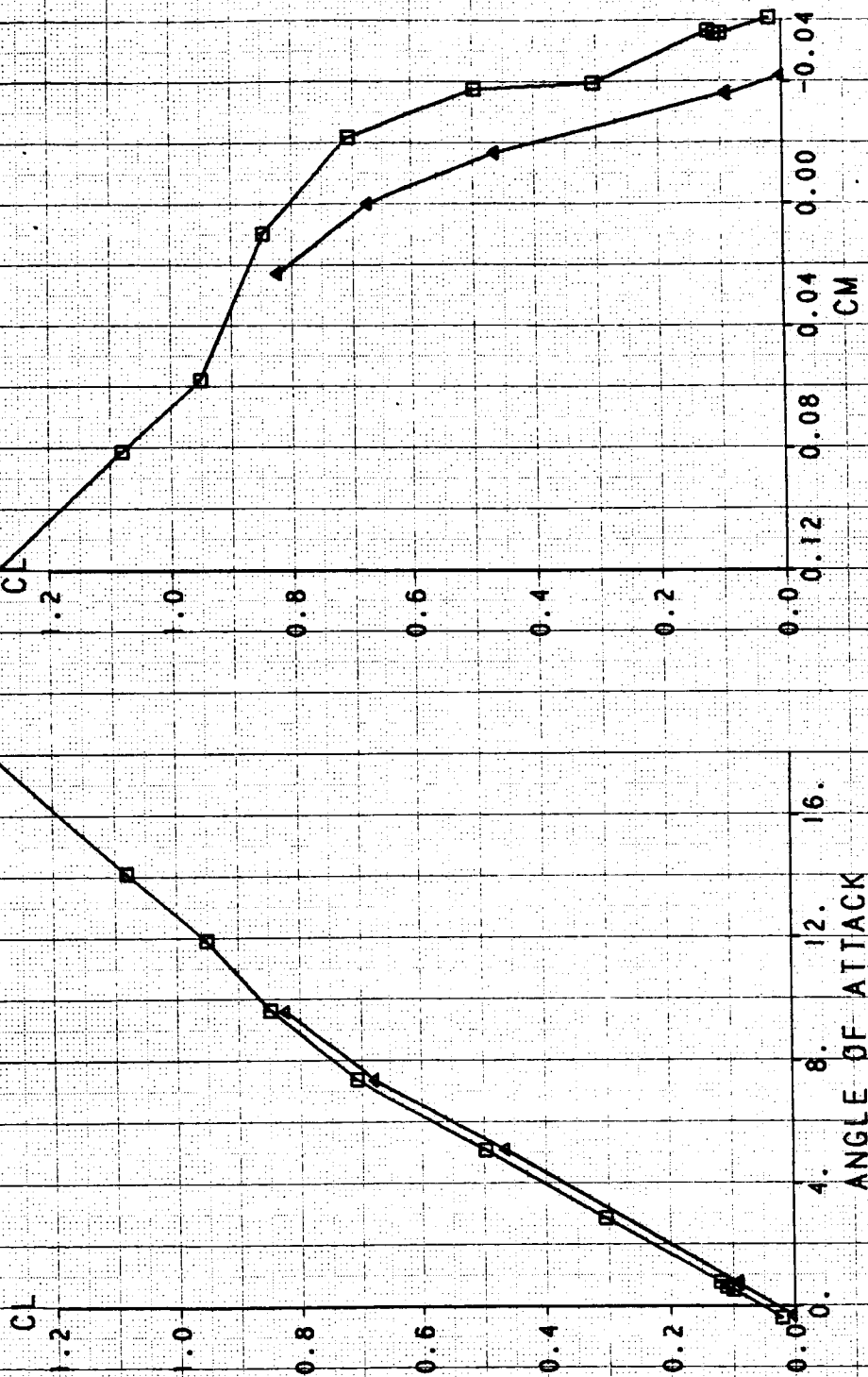
CANARD ROTATION EFFECT ON CLA VS AOA AND CMA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
□	514	164	0.3996	1.1079	5.0449
◄	514	165	0.3989	1.2024	-0.0455
◇	514	167	0.4016	1.1343	-4.9956
○	514	168	0.3985	1.2163	-10.002
◆	514	169	0.3983	1.2087	-15.006

CANARD ROTATION EFFECTS ON CLA VS CDA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
□	514	173	0.5990	0.9221	-0.0564
◄	514	172	0.5994	0.9207	-4.9770
◇	514	171	0.5994	0.9211	-10.014
⊖	514	170	0.6001	0.9175	-14.987

CANARD ROTATION EFFECT ON CLA VS AOA AND CMA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
□	514	173	0.5990	0.9221	-0.0564
◄	514	172	0.5994	0.9207	-4.9770
◆	514	171	0.5994	0.9211	-10.014
⊕	514	170	0.6001	0.9175	-14.987

CANARD ROTATION EFFECTS ON CLA VS CDA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
□	514	155	0.9018	0.8674	-0.0601
▲	514	156	0.9022	0.8692	-4.9921
◇	514	157	0.9020	0.8674	-10.000
⊖	514	158	0.9020	0.8695	-15.025

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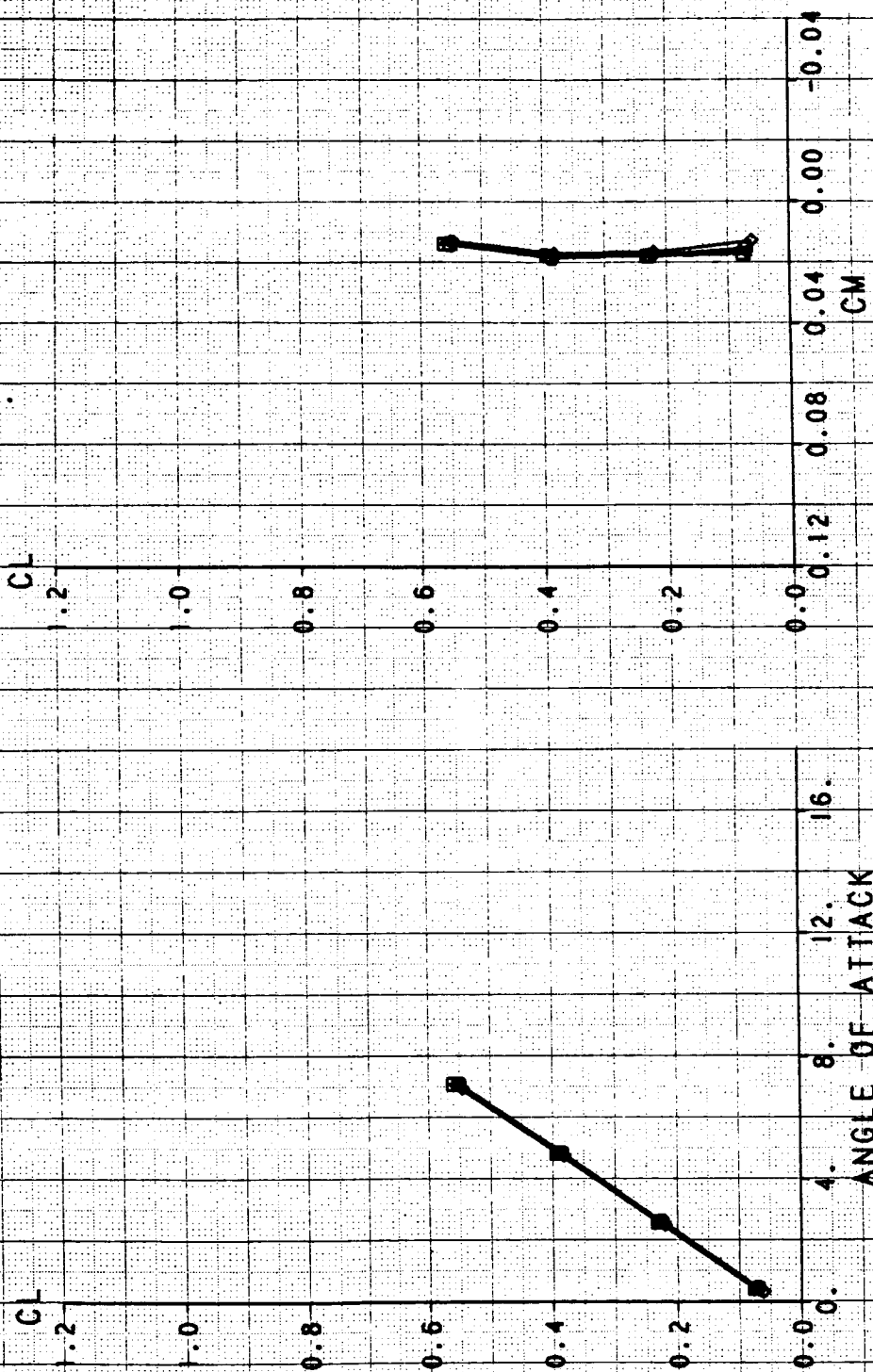CANARD ROTATION EFFECT ON CLA VS AOA AND CMA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
□	514	155	0.9018	0.8674	-0.0601
▲	514	156	0.9022	0.8692	-4.9921
◇	514	157	0.9020	0.8674	-10.000
⊕	514	158	0.9020	0.8695	-15.025

CANARD ROTATION EFFECTS ON CLA VS CDA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
⊡	514	160	1.1972	0.8895	-0.0539
▲	514	159	1.1977	0.8895	-4.9745

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CANARD ROTATION EFFECT ON CLA VS AOA AND CMA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL
☐	514	160	1.1972	0.8895	-0.0539
▲	514	159	1.1977	0.8895	-4.9745

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CANARD ROTATION EFFECTS ON CLA VS CDA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RWFR	RDELCL
□	514	161	1.3936	0.9250	-0.0567
▲	514	162	1.3939	0.9261	-4.9931

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CANARD ROTATION EFFECT ON CLA VS AOA AND CMA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RWFR	RDELCL
□	514	161	1.3936	0.9250	-0.0567
▲	514	162	1.3939	0.9261	-4.993T

CANARD ROTATION EFFECT ON DRAG POLAR
FT MODE IN COMMON BASELINE CONFIGURATION

SYM	TEST	RUN	RMACH	RDELCL
⊡	514	66	0.3993	5.0293
▲	514	67	0.3989	-0.0547
◇	514	68	0.3990	-5.0061
⊙	514	69	0.3989	-10.026
✦	514	70	0.3990	-15.003

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CANARD ROTATION EFFECT ON CL VS AOA AND CM
FT MODE IN COMMON BASELINE CONFIGURATION

SYM	TEST	RUN	RMACH	RDELCL
□	514	66	0.3993	5.0293
◄	514	67	0.3989	-0.0547
◇	514	68	0.3990	-5.0061
○	514	69	0.3989	-10.026
⬥	514	70	0.3990	-15.003

ANGLE OF ATTACK

CM

CL

CANARD ROTATION EFFECT ON DRAG POLAR
FT MODE IN COMMON BASELINE CONFIGURATION

SYM	TEST	RUN	RMACH	RDELCL
□	514	75	0.6005	5.0269
◄	514	74	0.6008	0.0827
◇	514	73	0.5997	-5.0066
⊖	514	72	0.5996	-10.035
✳	514	71	0.5986	-15.005

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CANARD ROTATION EFFECT ON CL VS AOA AND CM
FT MODE IN COMMON BASELINE CONFIGURATION

SYM	TEST	RUN	RMACH	RDELCL
□	514	75	0.6005	5.0269
◁	514	74	0.6008	0.0827
◇	514	73	0.5997	-5.0066
○	514	72	0.5996	-10.035
✳	514	71	0.5986	-15.005

CL

ANGLE OF ATTACK

CM

CANARD ROTATION EFFECT ON DRAG POLAR
FT MODE IN COMMON BASELINE CONFIGURATION

SYM	TEST	RUN	RMACH	RDELCL
□	514	77	0.9038	5.0182
▲	514	78	0.9010	-.00967
◇	514	79	0.9018	-5.0632
⊖	514	80	0.9011	-10.049
✦	514	81	0.9022	-15.034

CANARD ROTATION EFFECT ON CL VS AOA AND CM
FT MODE IN COMMON BASELINE CONFIGURATION

SYM	TEST	RUN	RMACH	RDELCL
□	514	77	0.9038	5.0182
◄	514	78	0.9010	-.00967
◇	514	79	0.9018	-5.0632
○	514	80	0.9011	-10.049
✳	514	81	0.9022	-15.034

CANARD ROTATION. EFFECT ON DRAG POLAR
FT MODE IN COMMON BASELINE CONFIGURATION

SYM	TEST	RUN	RMACH	RDELCL
☐	514	82	1.1884	5.0133
◄	514	85	1.1970	-0.0308
◇	514	86	1.1969	-5.0400
⊖	514	87	1.1969	-10.025

CANARD ROTATION EFFECT ON CL VS AOA AND CM
FT MODE IN COMMON BASELINE CONFIGURATION

SYM	TEST	RUN	RMACH	RDELCL
▢	514	82	1.1884	5.0133
▲	514	85	1.1970	-0.0308
◆	514	86	1.1969	-5.0400
⊕	514	87	1.1969	-10.025

CANARD ROTATION EFFECT ON DRAG POLAR
FT MODE IN COMMON BASELINE CONFIGURATION

SYM	TEST	RUN	RMACH	RDELCL
☐	514	93	1.3899	5.1040
▲	514	92	1.3923	-0.0318
◇	514	94	1.3917	-4.9583
⊙	514	95	1.3908	-10.046

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CANARD ROTATION EFFECT ON CL VS AOA AND CM
FT MODE IN COMMON BASELINE CONFIGURATION

SYM	TEST	RUN	RMACH	RDELCL
☐	514	93	1.3899	5.1040
▲	514	92	1.3923	-0.0318
◆	514	94	1.3917	-4.9583
⊖	514	95	1.3908	-10.046

CMAPS CANARD ROTATION EFFECT ON DRAG POLAR
MODE IN SIMULATED AIRCRAFT CONFIGURATION

SYM	TEST	RUN	RMACH	RNPRA	RMFR	RDELCL	DESCRIPTION
□	514	277	0.4012	2.8538	1.1551	0.1416	CMAPS,SIMULATED AIRCRAFT
▲	514	286	0.4019	2.8778	1.1505	-5.0028	CMAPS,SIMULATED AIRCRAFT

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CANARD ROTATION EFFECT ON CL VS AOA AND CM
CMAPS MODE IN SIMULATED AIRCRAFT CONFIGURATION

SYM	TEST	RUN	RMACH	RNPRA	RMFR	RDELCL	DESCRIPTION
□	514	277	0.4012	2.8538	1.1551	0.1416	CMAPS,SIMULATED AIRCRAFT
△	514	286	0.4019	2.8778	1.1505	-5.0028	CMAPS,SIMULATED AIRCRAFT

CANARD ROTATION EFFECT ON DRAG POLAR
CMAPS MODE IN SIMULATED AIRCRAFT CONFIGURATION

SYM	TEST	RUN	RMACH	RNPRA	RMFR	RDELCL	DESCRIPTION
□	514	178	0.6009	3.8301	0.9161	0.1001	CMAPS,SIMULATED AIRCRAFT
△	514	179	0.6010	3.8557	0.9158	-4.9809	CMAPS,SIMULATED AIRCRAFT
◇	514	180	0.6010	3.8478	0.9169	-10.081	CMAPS,SIMULATED AIRCRAFT
⊖	514	182	0.5994	3.8168	0.9215	-14.883	CMAPS,SIMULATED AIRCRAFT

CANARD ROTATION EFFECT ON CL VS AOA AND CM
CMAPS MODE IN SIMULATED AIRCRAFT CONFIGURATION

SYM	TEST	RUN	RMACH	RNPRA	RNFR	RDELCL	DESCRIPTION
☐	514	178	0.6009	3.8301	0.9161	0.1001	CMAPS,SIMULATED AIRCRAFT
◄	514	179	0.6010	3.8557	0.9158	-4.9809	CMAPS,SIMULATED AIRCRAFT
◇	514	180	0.6010	3.8478	0.9169	-10.081	CMAPS,SIMULATED AIRCRAFT
⊕	514	182	0.5994	3.8168	0.9215	-14.883	CMAPS,SIMULATED AIRCRAFT

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CANARD ROTATION EFFECT ON DRAG POLAR
CMAPS MODE IN SIMULATED AIRCRAFT CONFIGURATION

SYM	TEST	RUN	RMACH	RNPRA	RMFR	RDELCL	DESCRIPTION
□	514	197	0.9031	5.4208	0.7501	0.0791	CMAPS,SIMULATED AIRCRAFT
▲	514	215	0.8964	5.3011	0.7534	-4.9625	CMAPS,SIMULATED AIRCRAFT
◇	514	231	0.9032	5.3161	0.7544	-10.143	CMAPS,SIMULATED AIRCRAFT

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CANARD ROTATION EFFECT ON CL VS AOA AND CM
CMAPS MODE IN SIMULATED AIRCRAFT CONFIGURATION.

SYM	TEST	RUN	RMACH	RNPRA	RMFR	RDELCL	DESCRIPTION
▢	514	197	0.9031	5.4208	0.7501	0.0791	CMAPS,SIMULATED AIRCRAFT
▲	514	215	0.8964	5.3011	0.7534	-4.9625	CMAPS,SIMULATED AIRCRAFT
◆	514	231	0.9032	5.3161	0.7544	-10.143	CMAPS,SIMULATED AIRCRAFT

CANARD ROTATION EFFECT ON DRAG POLAR
CMAPS MODE IN SIMULATED AIRCRAFT CONFIGURATION

SYM	TEST	RUN	RMACH	RNPRA	RNFR	RDELCL	DESCRIPTION
□	514	242	1.1906	7.5840	0.7579	0.1042	CMAPS,SIMULATED AIRCRAFT
△	514	249	1.1920	7.5379	0.7579	-5.0946	CMAPS,SIMULATED AIRCRAFT

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CANARD ROTATION EFFECT ON CL VS AOA AND CM
CMAPS MODE IN SIMULATED AIRCRAFT CONFIGURATION

SYM	TEST	RUN	RMACH	RNPRA	RWFR	RDELCL	DESCRIPTION
□	514	242	1.1906	7.5840	0.7579	0.1042	CMAPS.SIMULATED AIRCRAFT
△	514	249	1.1920	7.5379	0.7579	-5.0946	CMAPS.SIMULATED AIRCRAFT

CL

CM

ANGLE OF ATTACK

CANARD ROTATION EFFECT ON DRAG POLAR
CMAPS MODE IN SIMULATED AIRCRAFT CONFIGURATION

SYM	TEST	RUN	RMACH	RNPRA	RMFR	RDELCL	DESCRIPTION
□	514	256	1.3969	9.5970	0.7929	0.1083	CMAPS,SIMULATED AIRCRAFT
△	514	263	1.3970	9.6047	0.7915	-5.0666	CMAPS,SIMULATED AIRCRAFT

CANARD ROTATION EFFECT ON CL VS AOA AND CM
CMAPS MODE IN SIMULATED AIRCRAFT CONFIGURATION

SYM	TEST	RUN	RMACH	RNPRA	RMFR	RDELCL	DESCRIPTION
⊡	514	256	1.3969	9.5970	0.7929	0.1083	CMAPS,SIMULATED AIRCRAFT
▲	514	263	1.3970	9.6047	0.7915	-5.0666	CMAPS,SIMULATED AIRCRAFT

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WING FLAP AND COWL LIP EFFECT ON CLA VS CDA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL	DESCRIPTION
□	514	177	0.3983	1.1156	-0.0437	FLOW-THROUGH MODE WITH EJECTORS, 0° WING FLAP
▲	514	199	0.3992	1.1076	-0.0211	FLOW-THROUGH MODE WITH DROOP-LIP INLET, 30° WING FLAP

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C-3

WING FLAP AND COWL LIP EFFECT ON CLA VS AOA AND CMA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL	DESCRIPTION
□	514	177	0.3983	1.1156	-0.0437	FLOW-THROUGH MODE WITH EJECTORS / 0° WING FLAP
△	514	199	0.3992	1.1076	-0.0213	FLOW-THROUGH MODE WITH DROOP-LIP / INLET / 30° WING FLAP

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COWL LIP ROTATION EFFECT ON CLA VS CDA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL	DESCRIPTION
□	514	172	0.5994	0.9207	-4.9770	FLOW-THROUGH MODE WITH EJECTORS
△	514	215	0.6001	0.8510	-4.9801	FLOW-THROUGH MODE WITH DROOP-LIP INLET

COWL LIP ROTATION EFFECT ON CLA VS AOA AND CMA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL	DESCRIPTION
☐	514	172	0.5994	0.9207	-4.9770	FLOW-THROUGH MODE WITH EJECTORS
▲	514	215	0.6001	0.8510	-4.9801	FLOW-THROUGH MODE WITH DROOP-LIP INLET

CLA

CMA

CLA

ANGLE OF ATTACK

COWL LIP ROTATION EFFECT ON CLA VS CDA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL	DESCRIPTION
▢	514	156	0.9022	0.8692	-4.9921	FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS
△	514	214	0.9001	0.8528	-4.9963	FLOW-THROUGH MODE WITH DROOP-LIP INLET

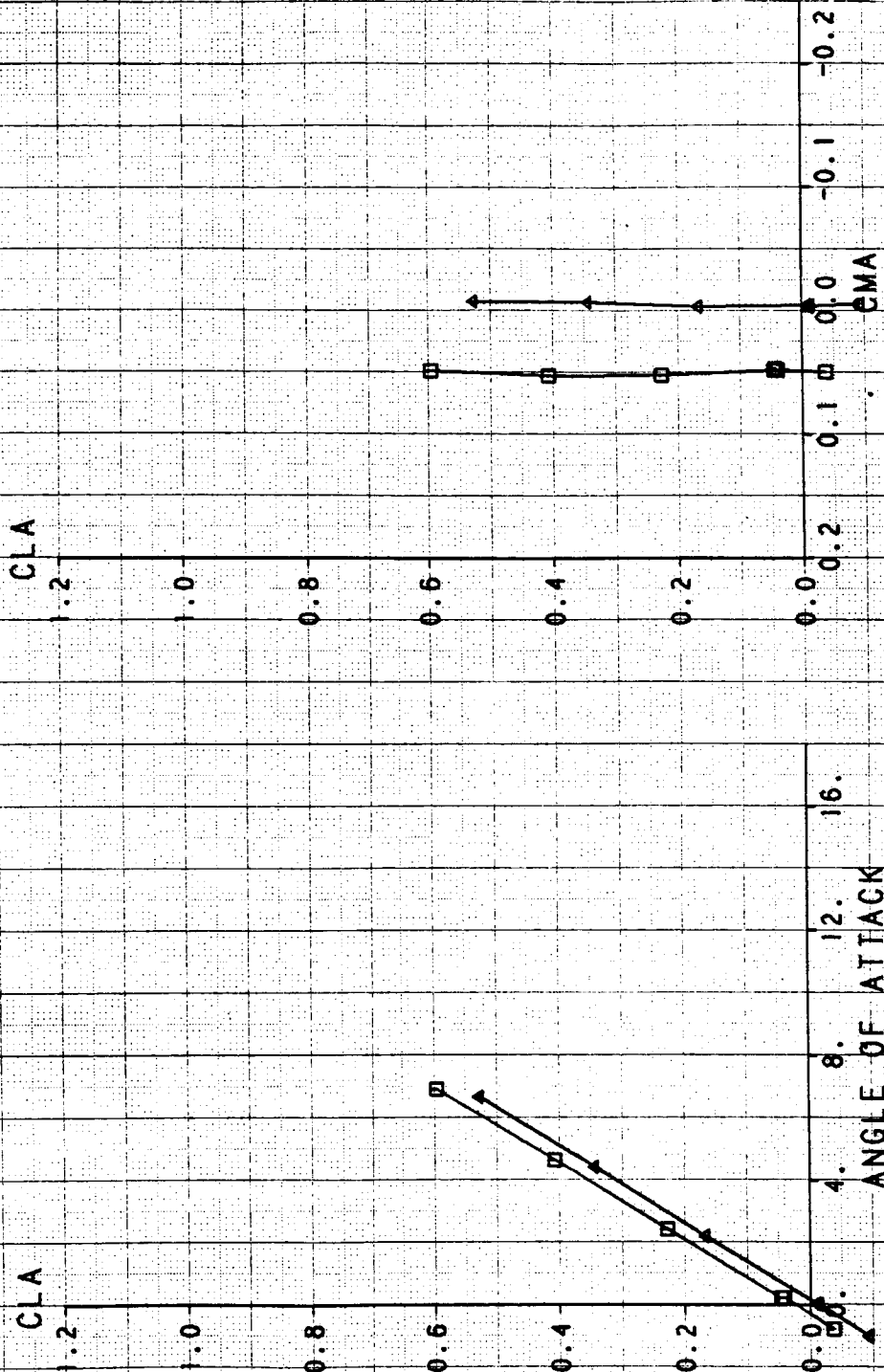COWL LIP ROTATION EFFECT ON CLA VS AOA AND CMA
FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS

SYM	TEST	RUN	RMACH	RMFR	RDELCL	DESCRIPTION
□	514	156	0.9022	0.8692	-4.9921	FLOW-THROUGH MODE WITH NOZZLE EXTENSIONS
▲	514	214	0.9001	0.8528	-4.9963	FLOW-THROUGH MODE WITH DROOP-LIP INLET

NOZZLE EXTENSION EFFECT ON CLA VS CDA
FLOW-THROUGH MODE DATA

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
□	514	68	0.3990	-5.0061	FLOW-THROUGH BASELINE
△	514	224	0.4020	-4.9936	FLOW-THROUGH MODE WITH INLETS FAIRED

NOZZLE EXTENSION EFFECT ON CLA VS AOA AND CMA
FLOW-THROUGH MODE DATA

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
□	514	68	0.3990	-5.0061	FLOW-THROUGH BASELINE
▲	514	224	0.4020	-4.9936	FLOW-THROUGH MODE WITH INLETS FAIRED

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NOZZLE EXTENSION EFFECT ON CLA VS CDA
FLOW-THROUGH MODE DATA

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
□	514	73	0.5997	-5.0066	FLOW-THROUGH BASELINE
△	514	223	0.5983	-4.9801	FLOW-THROUGH MODE WITH INLETS FAIRED

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NOZZLE EXTENSION EFFECT ON CLA VS AOA AND CMA
FLOW-THROUGH MODE DATA

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
☐	514	73	0.5997	-5.0066	FLOW-THROUGH BASELINE
△	514	223	0.5983	-4.9801	FLOW-THROUGH MODE WITH INLETS FAIRED

NOZZLE EXTENSION EFFECT ON CLA VS CDA
FLOW-THROUGH MODE DATA

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
▫	514	79	0.9018	-5.0632	FLOW-THROUGH BASELINE
△	514	222	0.9012	-4.9986	FLOW-THROUGH MODE WITH INLETS FAIRED

NOZZLE EXTENSION EFFECT ON CLA VS AOA AND CMA
FLOW-THROUGH MODE DATA

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
☐	514	79	0.9018	-5.0632	FLOW-THROUGH BASELINE
▲	514	222	0.9012	-4.9986	FLOW-THROUGH MODE WITH INLETS FAIRED

NOZZLE EXTENSION EFFECT ON CLA VS CDA
FLOW-THROUGH MODE DATA

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
□	514	85	1.1970	-0.0308	FLOW-THROUGH BASELINE
△	514	219	1.1944	-0.0561	FLOW-THROUGH MODE WITH INLETS FAIRED

NOZZLE EXTENSION EFFECT ON CLA VS AOA AND CMA
FLOW-THROUGH MODE DATA

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
□	514	85	1.1970	-0.0308	FLOW-THROUGH BASELINE
△	514	219	1.1944	-0.0561	FLOW-THROUGH MODE WITH INLETS FAIRED

NOZZLE EXTENSION EFFECT ON CLA VS CDA
FLOW-THROUGH MODE DATA

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
☐	514	92	1.3923	-0.0318	FLOW-THROUGH BASELINE
△	514	218	1.3930	-0.0607	FLOW-THROUGH MODE WITH INLETS FAIRED

NOZZLE EXTENSION EFFECT ON CLA VS AOA AND CMA
FLOW-THROUGH MODE DATA

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
□	514	92	1.3923	-0.0318	FLOW-THROUGH BASELINE
△	514	218	1.3930	-0.0607	FLOW-THROUGH MODE WITH INLETS FAIRED

DRAG POLAR COMPARISON FOR COMMON BASELINE CONFIGURATION
ALL TEST MODES

SYM	TEST	RUN	RMACH	RNPRA	RDELCL	DESCRIPTION
□	514	68	0.3990	9999.	-5.0061	FLOW-THROUGH MODE
△	514	238	0.3989	0.0637	-4.9629	JET-EFFECTS MODE
◇	514	106	0.4010	0.1402	-4.9780	CMAPS MODE
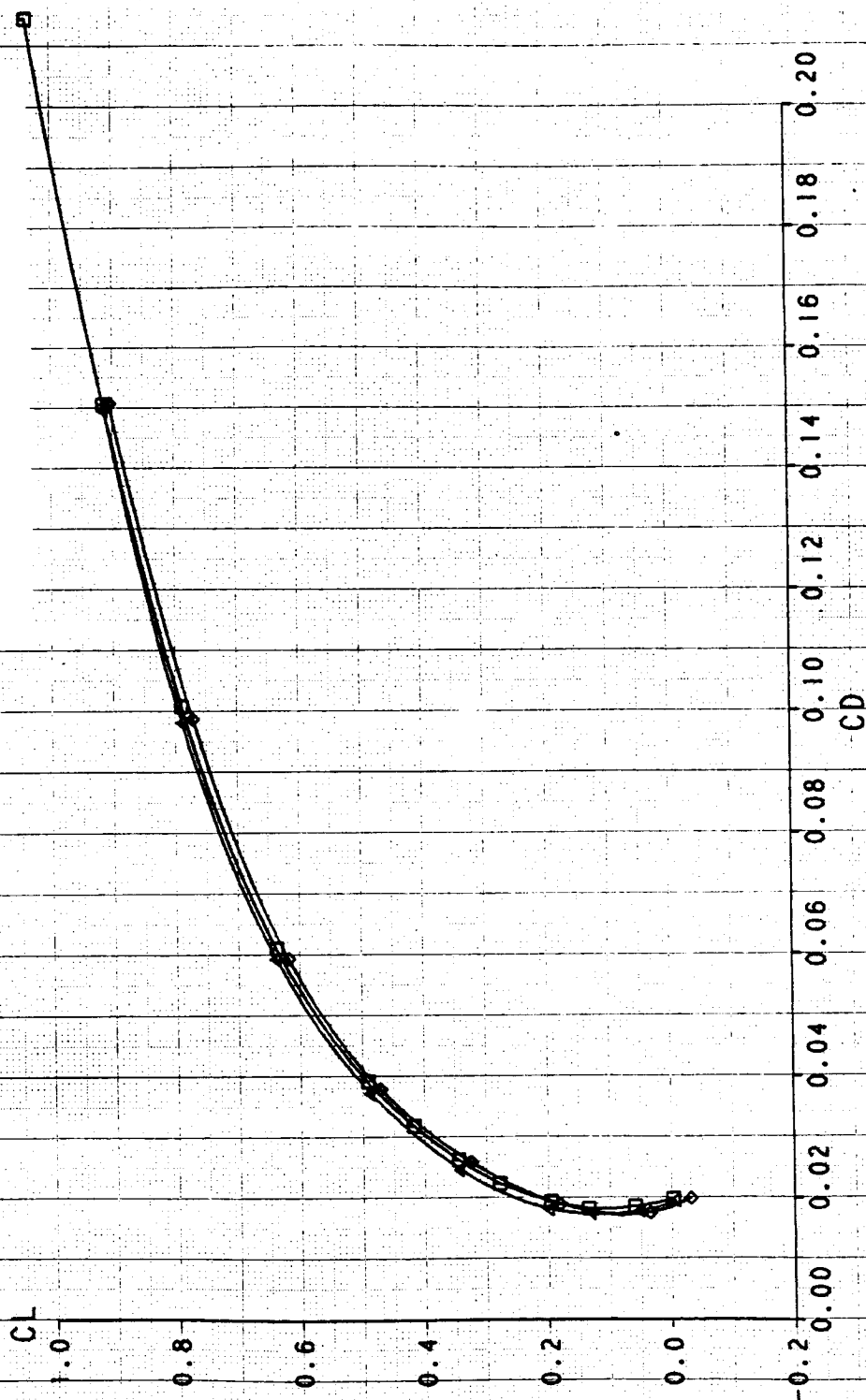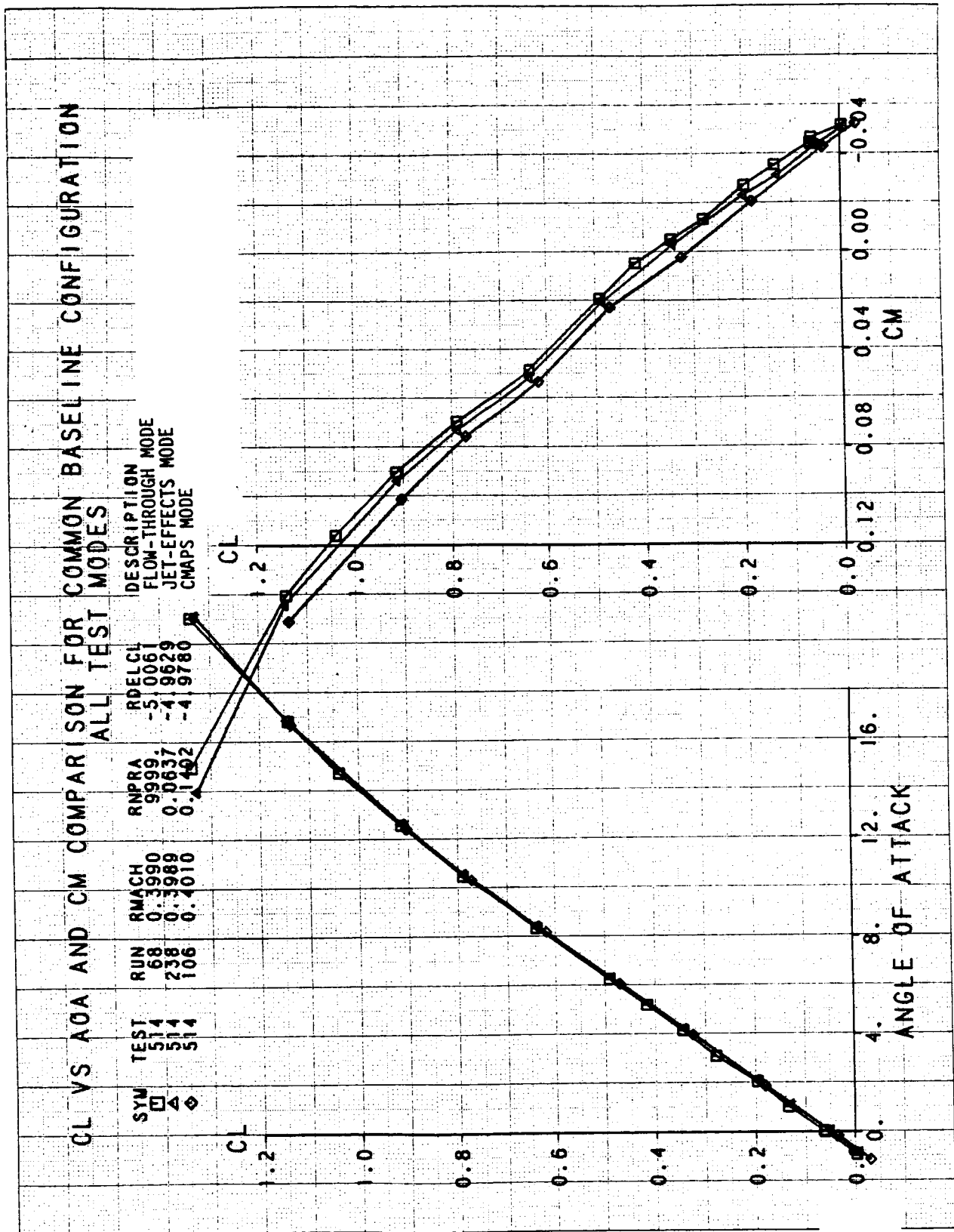
198

CL VS AOA AND CM COMPARISON FOR COMMON BASELINE CONFIGURATION
ALL TEST MODES

SYM	TEST	RUN	RMACH	RNPRA	RDELCL	DESCRIPTION
□	514	68	0.3990	9999.	-5.0061	FLOW-THROUGH MODE
△	514	238	0.3989	0.0637	-4.9629	JET-EFFECTS MODE
◇	514	106	0.4010	0.1492	-4.9780	CMAPS MODE

DRAG POLAR COMPARISON FOR COMMON BASELINE CONFIGURATION
ALL TEST MODES

SYM	TEST	RUN	RMACH	RNPRA	RDELCL	DESCRIPTION
☐	514	73	0.5997	9999.	-5.0066	FLOW-THROUGH MODE
△	514	243	0.6214	0.0906	-4.9911	JET-EFFECTS MODE
◇	514	109	0.5999	0.1407	-4.9645	CMAPS MODE
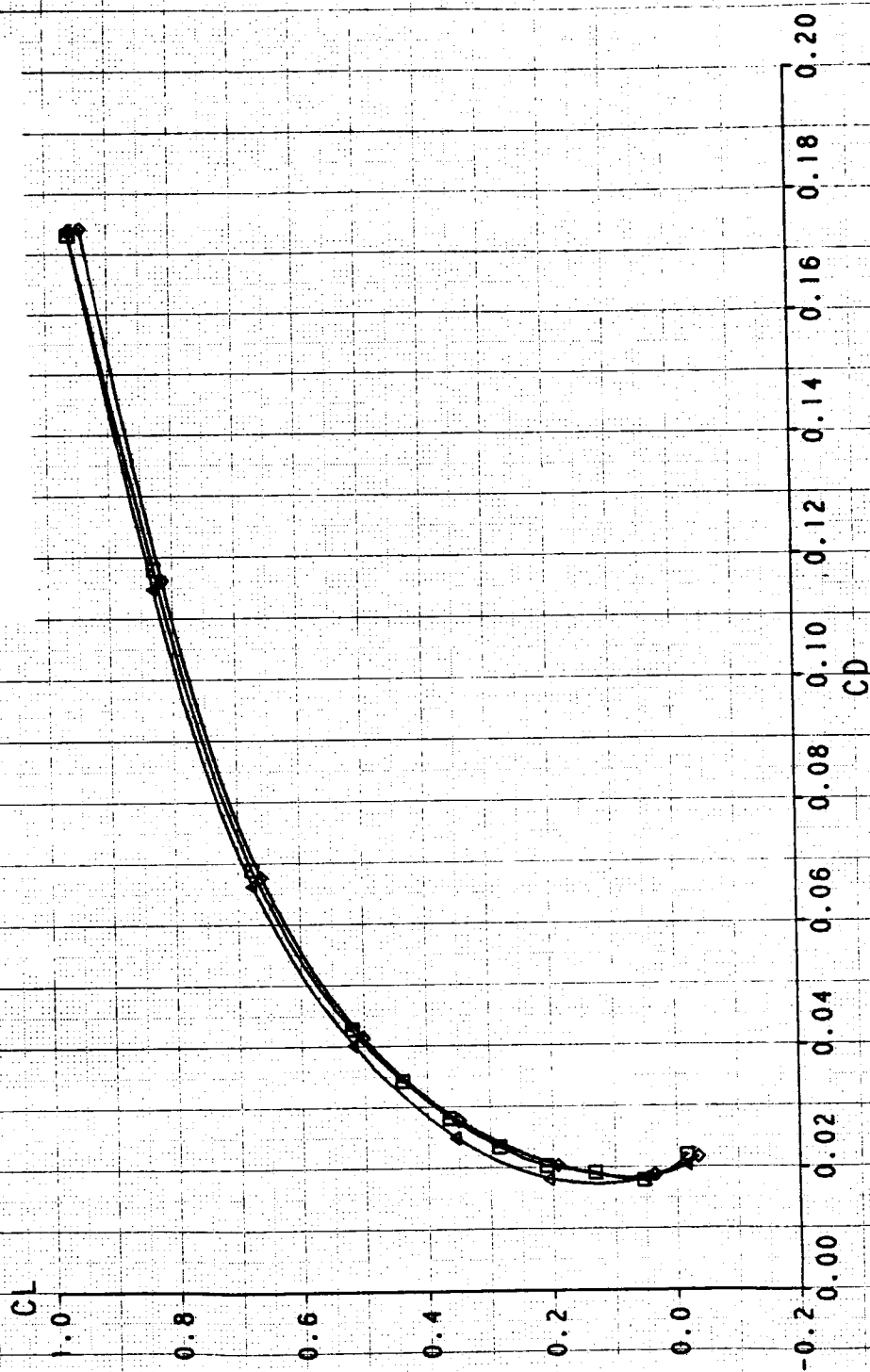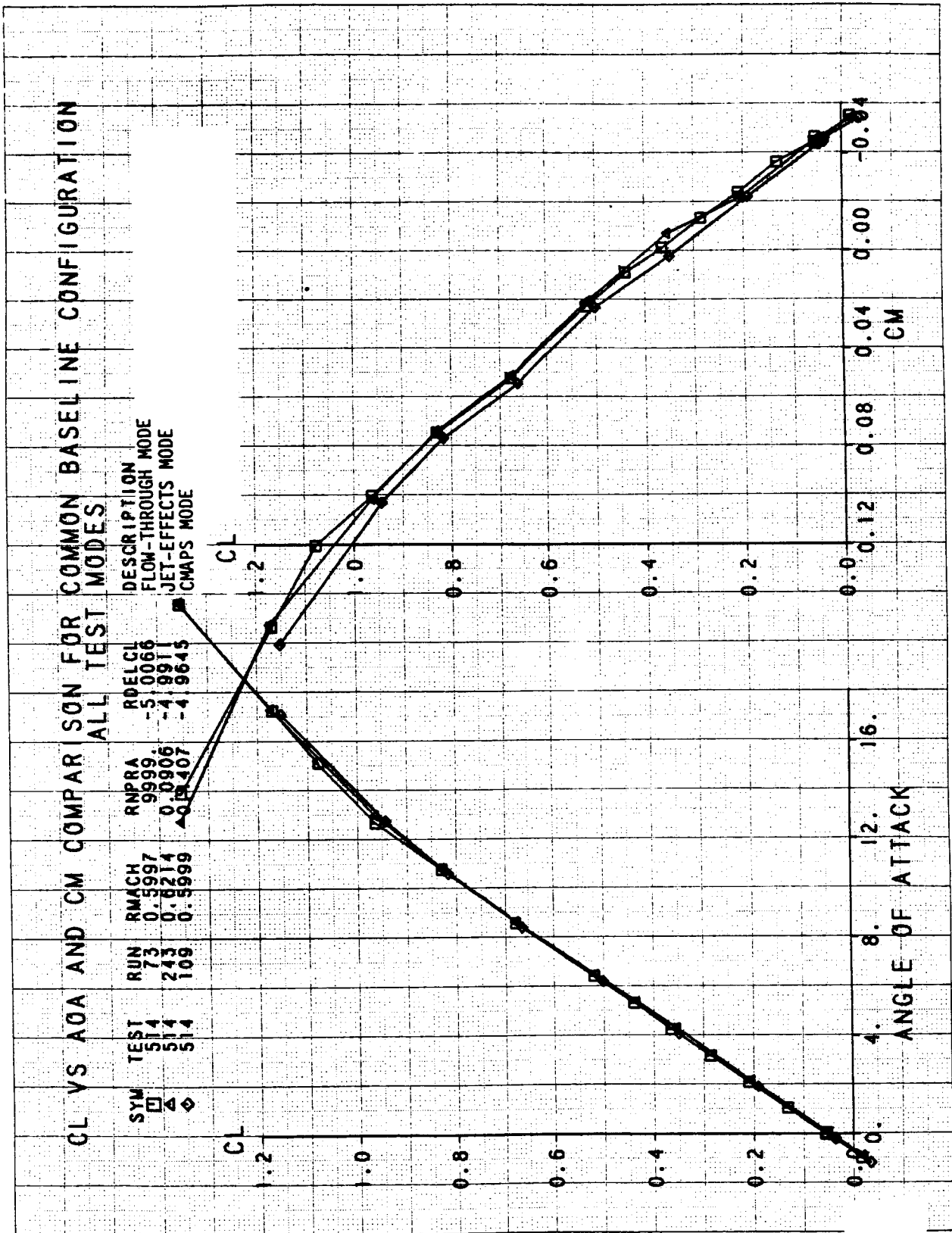
CL VS AOA AND CM COMPARISON FOR COMMON BASELINE CONFIGURATION
ALL TEST MODES

SYM	TEST	RUN	RMACH	RNPRA	RDELCL	DESCRIPTION
☐	514	73	0.5997	9999.	-5.0066	FLOW-THROUGH MODE
△	514	243	0.6214	0.0906	-4.9911	JET-EFFECTS MODE
◇	514	109	0.5999	0.9407	-4.9645	CMAPS MODE

CL

CM

ANGLE OF ATTACK

DRAG POLAR COMPARISON FOR COMMON BASELINE CONFIGURATION
ALL TEST MODES

SYM	TEST	RUN	RMACH	RNPRA	RDELCL	DESCRIPTION
□	514	79	0.9018	9999.	-5.0632	FLOW-THROUGH MODE
△	514	244	0.9022	0.1384	-4.9674	JET-EFFECTS MODE
◇	514	110	0.8980	0.1426	-4.9715	CMAPS MODE

CL VS AOA AND CM COMPARISON FOR COMMON BASELINE CONFIGURATION
ALL TEST MODES

SYM	TEST	RUN	RMACH	RNPRA	RDELCL	DESCRIPTION
□	514	79	0.9018	9999.	-5.0632	FLOW-THROUGH MODE
△	514	244	0.9022	0.1384	-4.9674	JET-EFFECTS MODE
◇	514	110	0.8980	0.1426	-0.0715	CMAPS MODE

203

DRAG POLAR COMPARISON FOR COMMON BASELINE CONFIGURATION
ALL TEST MODES

SYM	TEST	RUN	RMACH	RNPRA	RDELCL	DESCRIPTION
□	514	85	1.1970	9999.	-0.0308	FLOW-THROUGH MODE
▲	514	245	1.1772	0.1893	-0.1056	JET-EFFECTS MODE
◇	514	111	1.1659	0.1145	-0.1546	CMAPS MODE

CL VS AOA AND CM COMPARISON FOR COMMON BASELINE CONFIGURATION
ALL TEST MODES

SYM	TEST	RUN	RMACH	RNPRA	RDELCL	DESCRIPTION
□	514	85	1.1970	9999.	-0.0308	FLOW-THROUGH MODE
△	514	245	1.1772	0.1893	-0.1056	JET-EFFECTS MODE
◇	514	111	1.1659	0.1145	0.1546	CMAPS MODE

205

DRAG POLAR COMPARISON FOR COMMON BASELINE CONFIGURATION
ALL TEST MODES

SYM	TEST	RUN	RMACH	RNPRA	RDELCL	DESCRIPTION
☐	514	92	1.3923	9999.	-0.0318	FLOW-THROUGH MODE
△	514	246	1.3548	0.2345	.00883	JET-EFFECTS MODE
◇	514	112	1.3555	0.1943	0.1456	CMAPS MODE

CL

CD

206

CL VS AOA AND CM COMPARISON FOR COMMON BASELINE CONFIGURATION ALL TEST MODES

SYM	TEST	RUN	RMACH	RNPRA	RDELCL	DESCRIPTION
□	514	92	1.3923	9999.	-0.0318	FLOW-THROUGH MODE
▲	514	246	1.3548	0.2345	.00883	JET-EFFECTS MODE
◇	514	112	1.3555	0.1943	0.1456	CMAPS MODE

INLET MASS FLOW RATIO EFFECT ON NOZZLE FORCE AND MOMENT DATA
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RDELCL	RMFR
□	514	122	0.6230	-4.9924	0.6812
△	514	123	0.5991	-4.9948	0.8057
◇	514	124	0.5993	-4.9974	0.9143

ALPHA = 0°

CLNOZ

CDNOZ

CMNOZ

NOZZLE PRESSURE RATIO

INLET MASS FLOW RATIO EFFECT ON CL, CD, AND CM VS NPR
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RMFR	RDELCL
□	514	122	0.6230	0.6812	-4.9924
▲	514	123	0.5991	0.8057	-4.9948
◆	514	124	0.5993	0.9143	-4.9974

ALPHA = 0°

INLET MASS FLOW RATIO EFFECT ON NOZZLE FORCE AND MOMENT DATA
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RDELCL	RMFR
□	514	138	0.5992	-5.0103	0.6896
▲	514	139	0.5986	-5.0136	0.7984
◇	514	140	0.5994	-5.0127	0.9018

ALPHA = 4.5°

INLET MASS FLOW RATIO EFFECT ON CL, CD, AND CM VS NPR
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RWFR	RDELCL
□	514	138	0.5992	0.6896	-5.0103
△	514	139	0.5986	0.7984	-5.0136
◇	514	140	0.5994	0.9018	-5.0127

ALPHA = 4.5°

211

INLET MASS FLOW RATIO EFFECT ON NOZZLE FORCE AND MOMENT DATA
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RDELCL	RMFR
□	514	153	0.6006	-4.9954	0.6730
△	514	154	0.6004	-5.0019	0.7657
◇	514	155	0.6001	-4.9679	0.8542

ALPHA = 9°

CMNOZ

CDNOZ

CLNOZ

NOZZLE PRESSURE RATIO

INLET MASS FLOW RATIO EFFECT ON CL, CD, AND CM VS NPR
SIMULATOR MODEL WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RWFR	RDELCL
□	514	153	0.6006	0.6730	-4.9954
▲	514	154	0.6004	0.7657	-5.0019
◆	514	155	0.6001	0.8542	-4.9679

ALPHA = 9°

213

INLET MASS FLOW RATIO EFFECT ON NOZZLE FORCE AND MOMENT DATA
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RDELCL	RMFR
□	514	167	0.6004	-4.9954	0.6097
△	514	168	0.6006	-4.9957	0.6843
◇	514	169	0.6008	-5.0001	0.7554

ALPHA = 17.5°

INLET MASS FLOW RATIO EFFECT ON CL, CD, AND CM VS NPR
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RWFR	RDELCL
☐	514	167	0.6004	0.6097	-4.9954
▲	514	168	0.6006	0.6843	-4.9957
◆	514	169	0.6008	0.7554	-5.0001

ALPHA = 17.5°

ANGLE OF ATTACK EFFECT ON NOZZLE FORCE AND MOMENT DATA
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RDELCL	RMFR	ALPHA
□	514	124	0.5993	-4.9974	0.9143	0°
▲	514	140	0.5994	-5.0127	0.9018	4.5°
◆	514	155	0.6001	-4.9679	0.8542	9°
⊖	514	169	0.6008	-5.0001	0.7554	17.5°
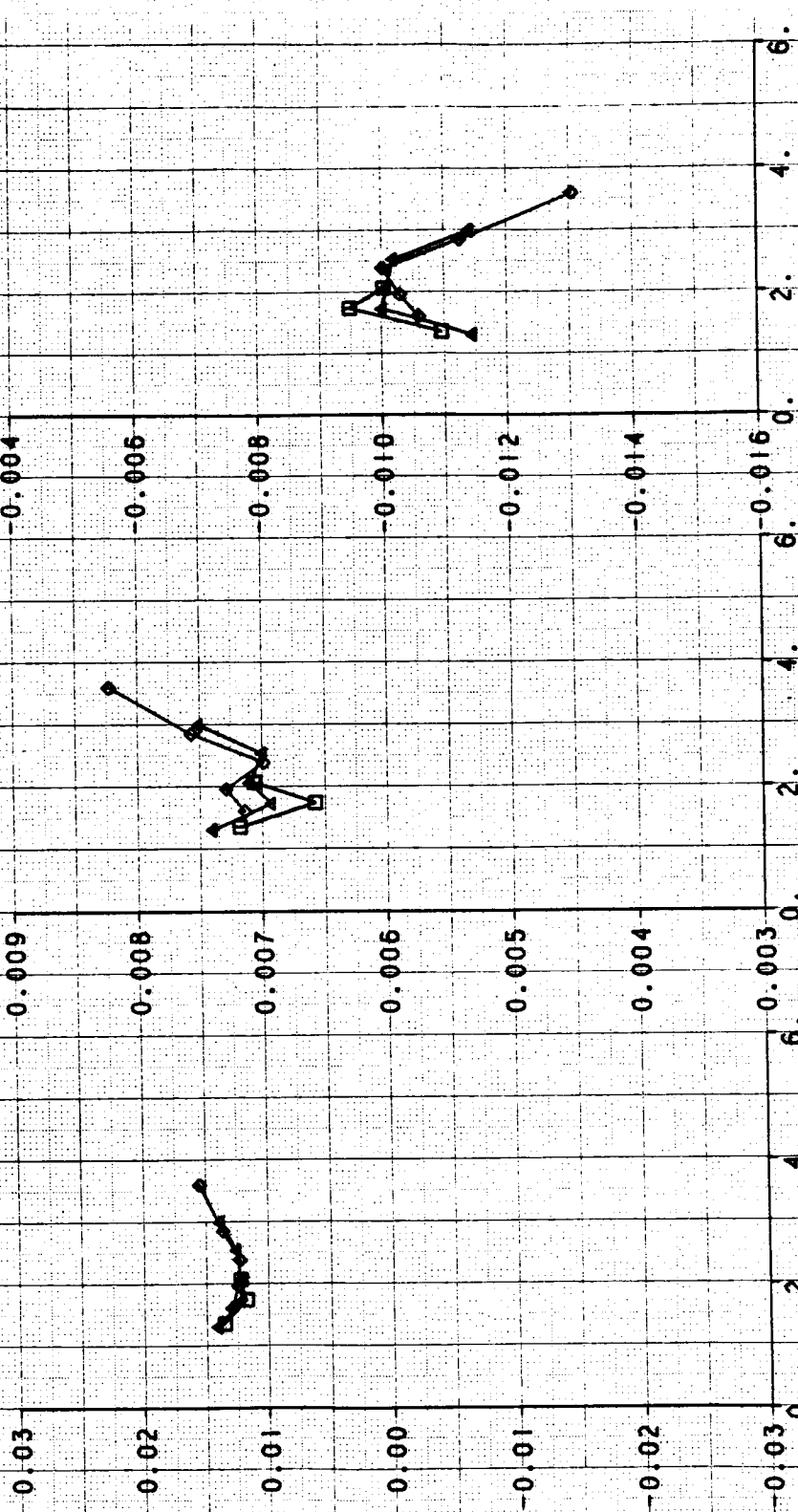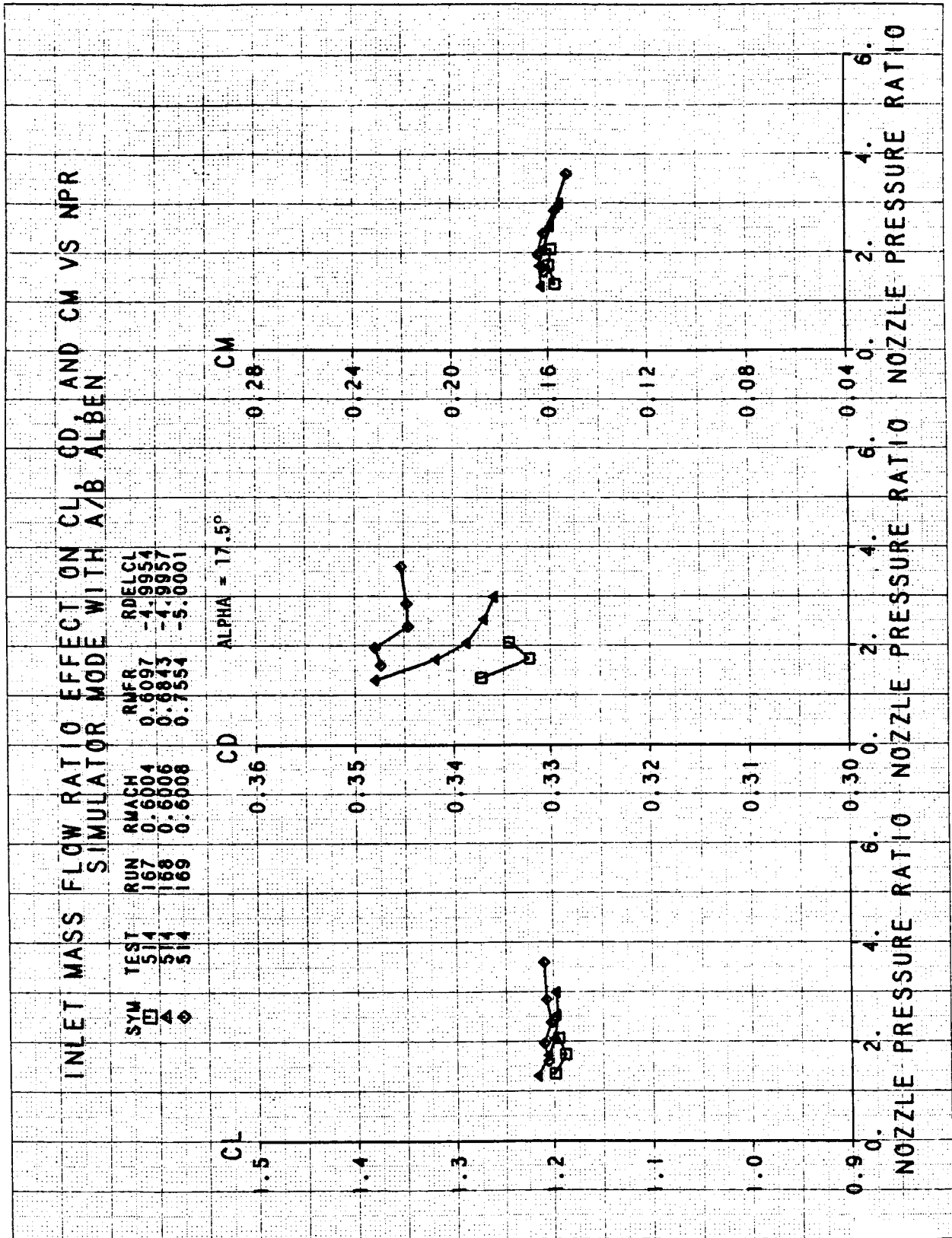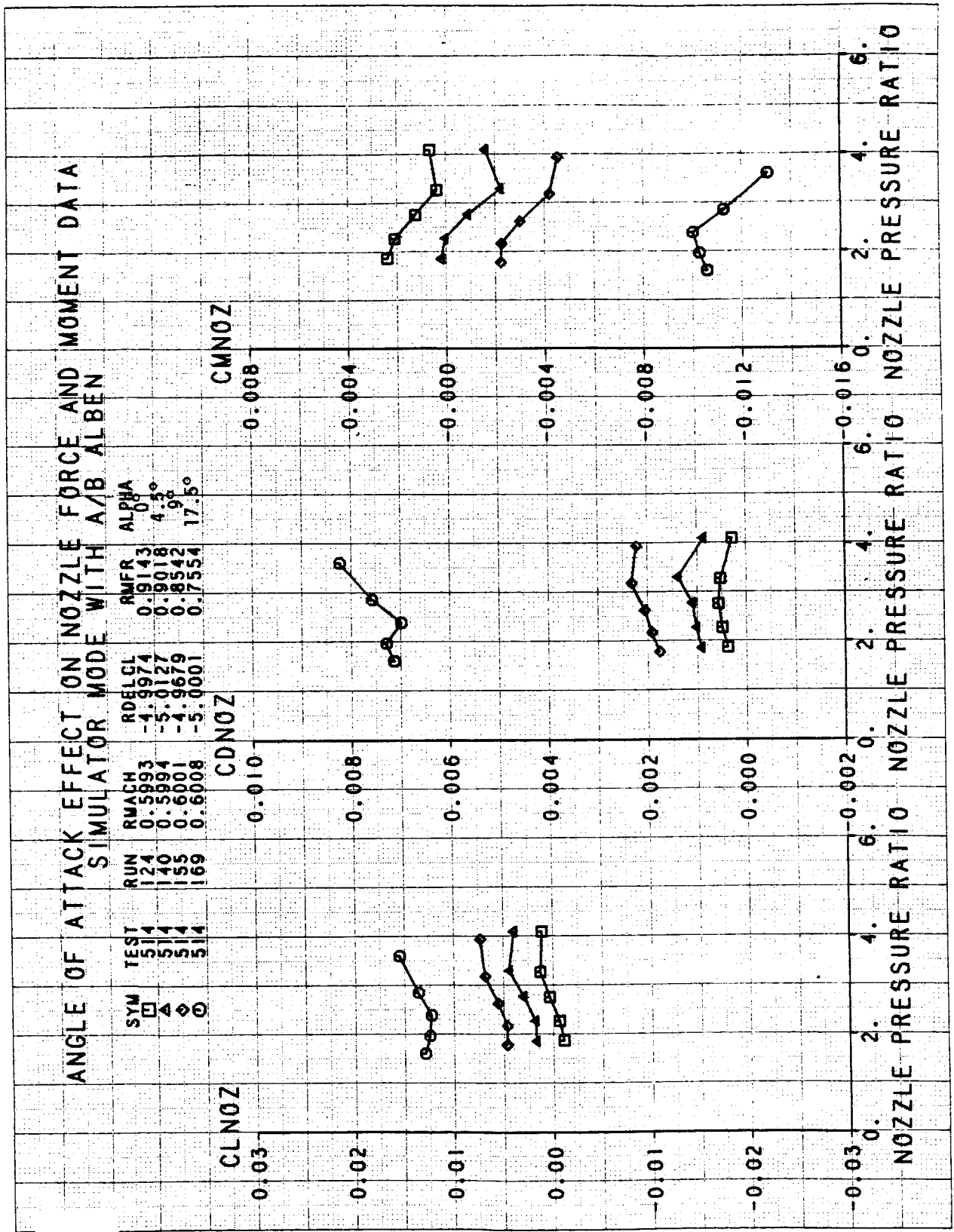
ANGLE OF ATTACK EFFECT ON CL, CD, AND CM VS NPR
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RWFR	RDELCL	ALPHA
▢	514	124	0.5993	0.9143	-4.9974	0°
▲	514	140	0.5994	0.9018	-5.0127	4.5°
◆	514	155	0.6001	0.8542	-4.9679	9°
⊕	514	169	0.6008	0.7554	-5.0001	1'.5°
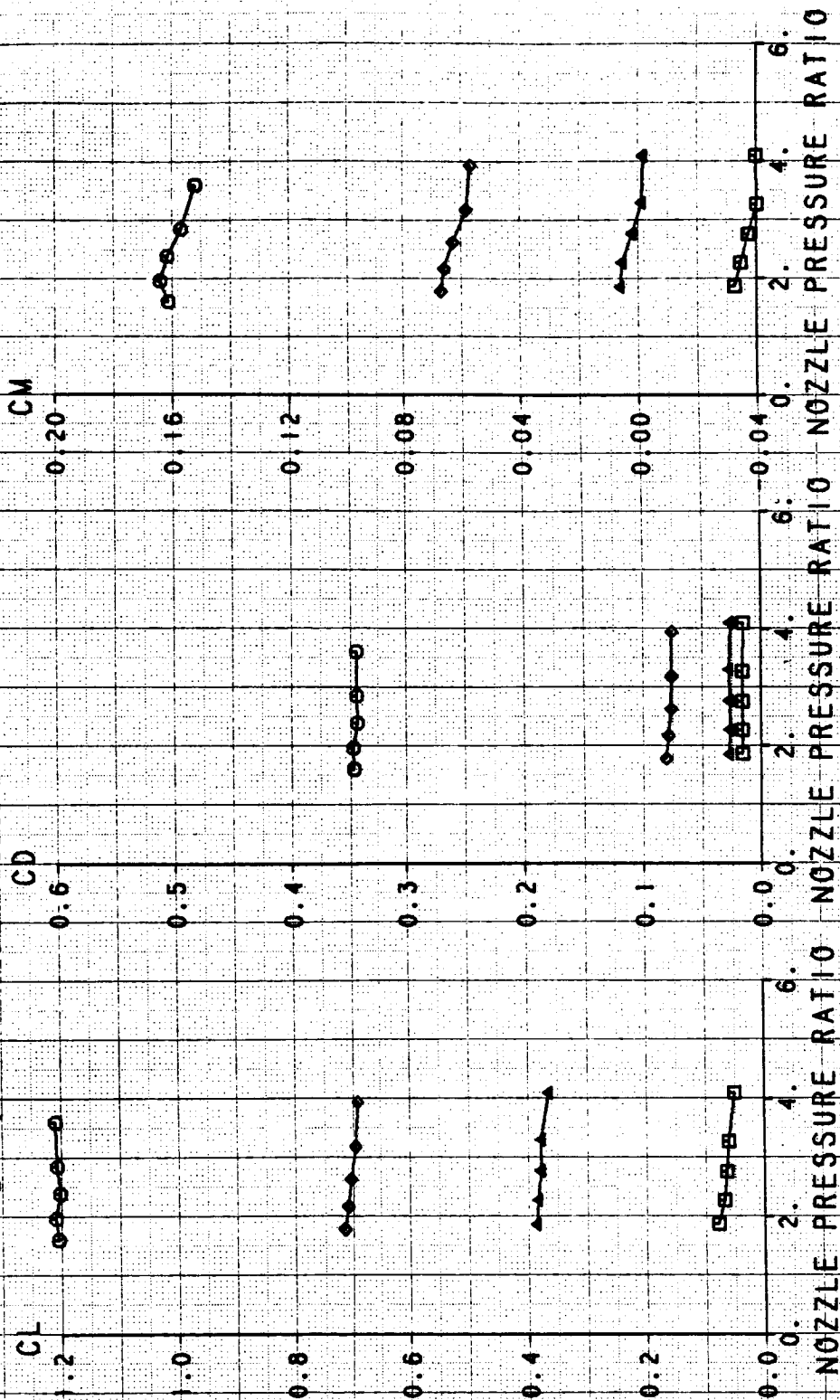
NOZZLE PRESSURE RATIO

CANARD ROTATION EFFECT ON NOZZLE FORCE AND MOMENT DATA
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RDELCL	RMFR
□	514	116	0.6003	0.1330	0.6905
△	514	122	0.6230	-4.9924	0.6812
◇	514	127	0.5991	-10.111	0.6886

ALPHA = 0°

CANARD ROTATION EFFECT ON CL, CD, AND CM VS NPR
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RNFR	RDELCL
□	514	116	0.6003	0.6905	0.1330
▲	514	122	0.6230	0.6812	-4.9924
◇	514	127	0.5991	0.6886	-10.111

ALPHA = 0°

CANARD ROTATION EFFECT ON NOZZLE FORCE AND MOMENT DATA
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RDELCL	RMFR
□	514	118	0.5994	0.1336	0.9107
△	514	124	0.5993	-4.9974	0.9143
◇	514	129	0.5995	-10.119	0.9187

ALPHA = 0°

CANARD ROTATION EFFECT ON CL, CD, AND CM VS NPR
SIMULATOR MODE WITH A/B, ALBEN
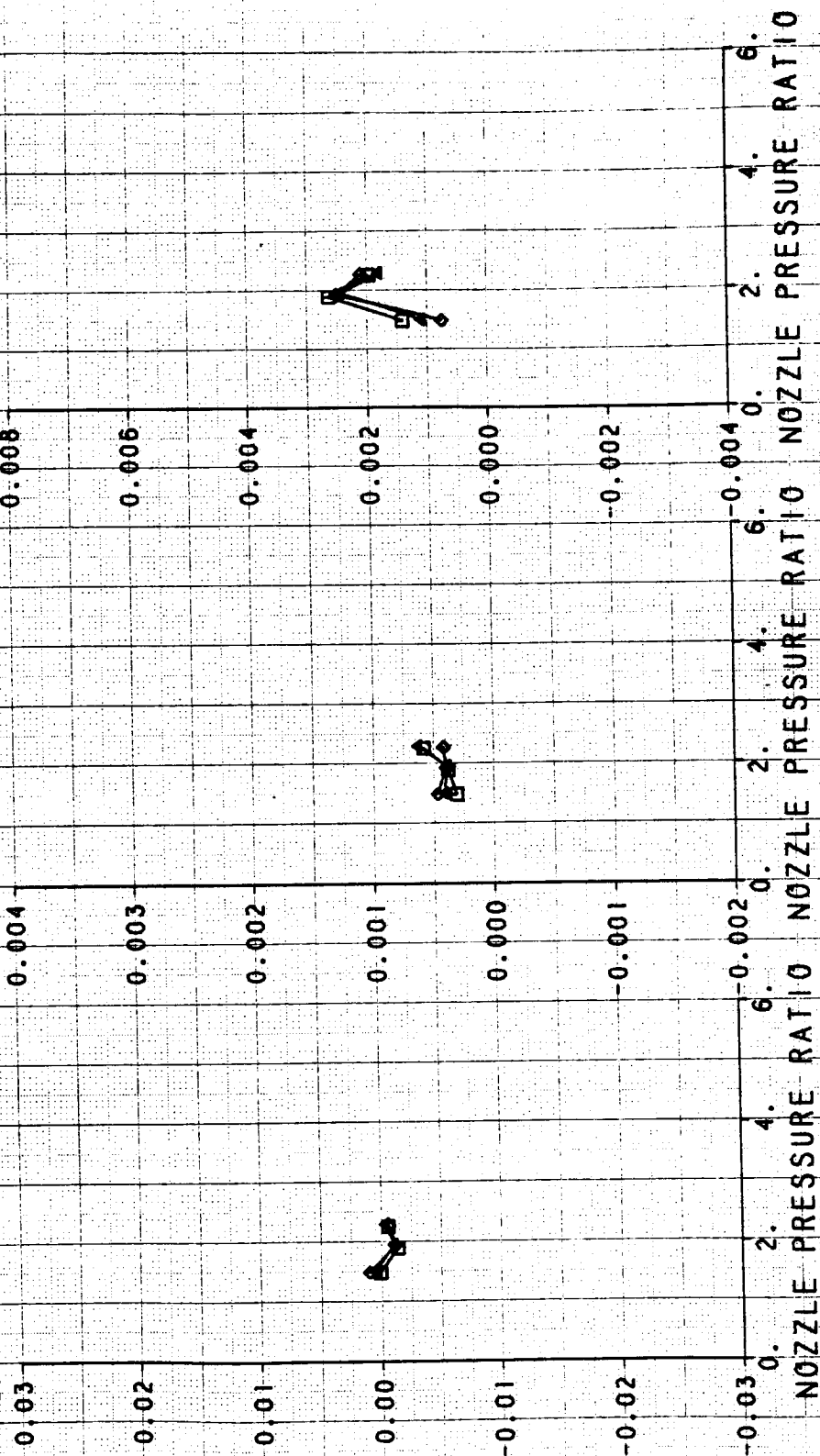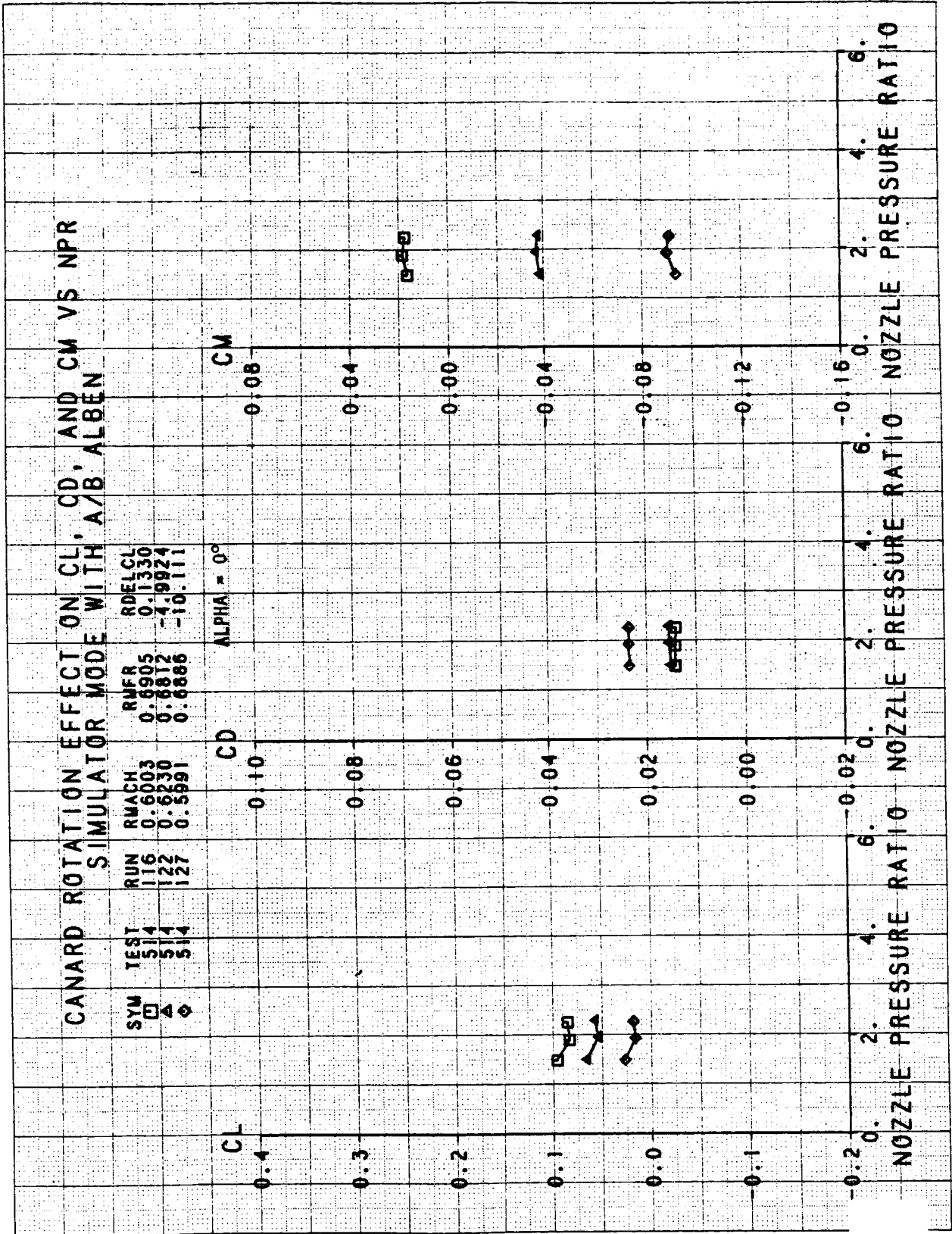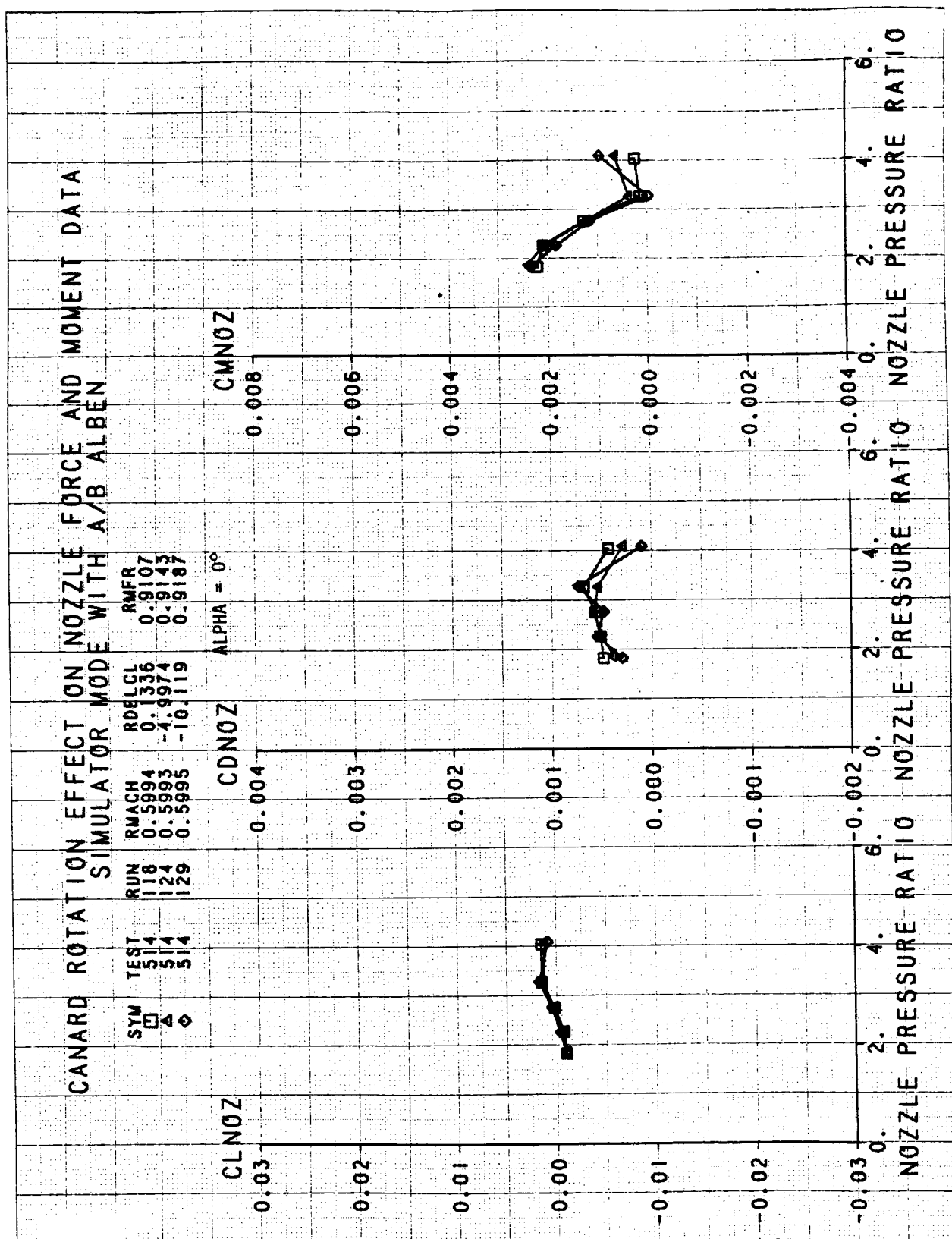
SYM	TEST	RUN	RMACH	RMFR	RDELCL
□	514	118	0.5994	0.9107	0.1336
▲	514	124	0.5995	0.9143	-4.9974
◇	514	129	0.5995	0.9187	-10.119

ALPHA = 0°

CANARD ROTATION EFFECT ON NOZZLE FORCE AND MOMENT DATA
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RDELCL	RMFR
□	514	162	0.6008	0.1122	0.6108
▲	514	167	0.6004	-4.9954	0.6097
◇	514	171	0.6018	-10.106	0.6120

ALPHA = 17.5°

CANARD ROTATION EFFECT ON CL, CD, AND CM VS NPR
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RNFR	RDELCL
□	514	162	0.6008	0.6108	0.1122
▲	514	167	0.6004	0.6097	-4.9954
◇	514	171	0.6018	0.6120	-10.106

ALPHA = 17.5°

CANARD ROTATION EFFECT ON NOZZLE FORCE AND MOMENT DATA
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RDELCL	RMFR
□	514	165	0.6034	0.1281	0.7508
▲	514	169	0.6008	-5.0001	0.7554
◆	514	173	0.5997	-10.172	0.7546

ALPHA = 17.5°

CANARD ROTATION EFFECT ON CL, CD, AND CM VS NPR
SIMULATOR MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RNPR	RDELCL
□	514	165	0.6034	0.7508	0.1261
▲	514	169	0.6008	0.7554	-5.0001
◆	514	173	0.5997	0.7546	-10.172

ALPHA = 17.5°

225

THRUST VECTORING EFFECT ON NOZZLE FORCE AND MOMENT DATA
JET-EFFECTS MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
☐	514	256	0.3973	-5.0527	JET-EFFECTS MODE:0 DEG VECTOR ALBEN A/B
▲	514	272	0.3992	-4.9042	JET-EFFECTS MODE:20 DEG VECTOR ALBEN A/B
◇	514	286	0.4010	-4.9704	JET-EFFECTS MODE:30 DEG VECTOR ALBEN A/B

ALPHA = 0°

THRUST VECTORING EFFECT ON CL, CD AND CM VS NPR
JET-EFFECTS MODE WITH A/B ALBEN

THRUST VECTORING EFFECT ON NOZZLE FORCE AND MOMENT DATA
JET-EFFECTS MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
▫	514	260	0.6012	-4.9908	JET-EFFECTS MODE:0 DEG VECTOR ALBEN A/B
▲	514	269	0.6011	-4.9144	JET-EFFECTS MODE:20 DEG VECTOR ALBEN A/B

ALPHA = 0°

CLNOZ

CDNOZ

CMNOZ

NOZZLE PRESSURE RATIO

THRUST VECTORING EFFECT ON CL, CD AND CM VS NPR
JET-EFFECTS MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
□	514	260	0.6012	-4.9908	JET-EFFECTS MODE;0 DEG VECTOR ALBEN A/B
△	514	269	0.6011	-4.9144	JET-EFFECTS MODE;20 DEG VECTOR ALBEN A/B

ALPHA = 0°

THRUST VECTORING EFFECT ON NOZZLE FORCE AND MOMENT DATA
JET-EFFECTS MODE WITH A/B ALBEN
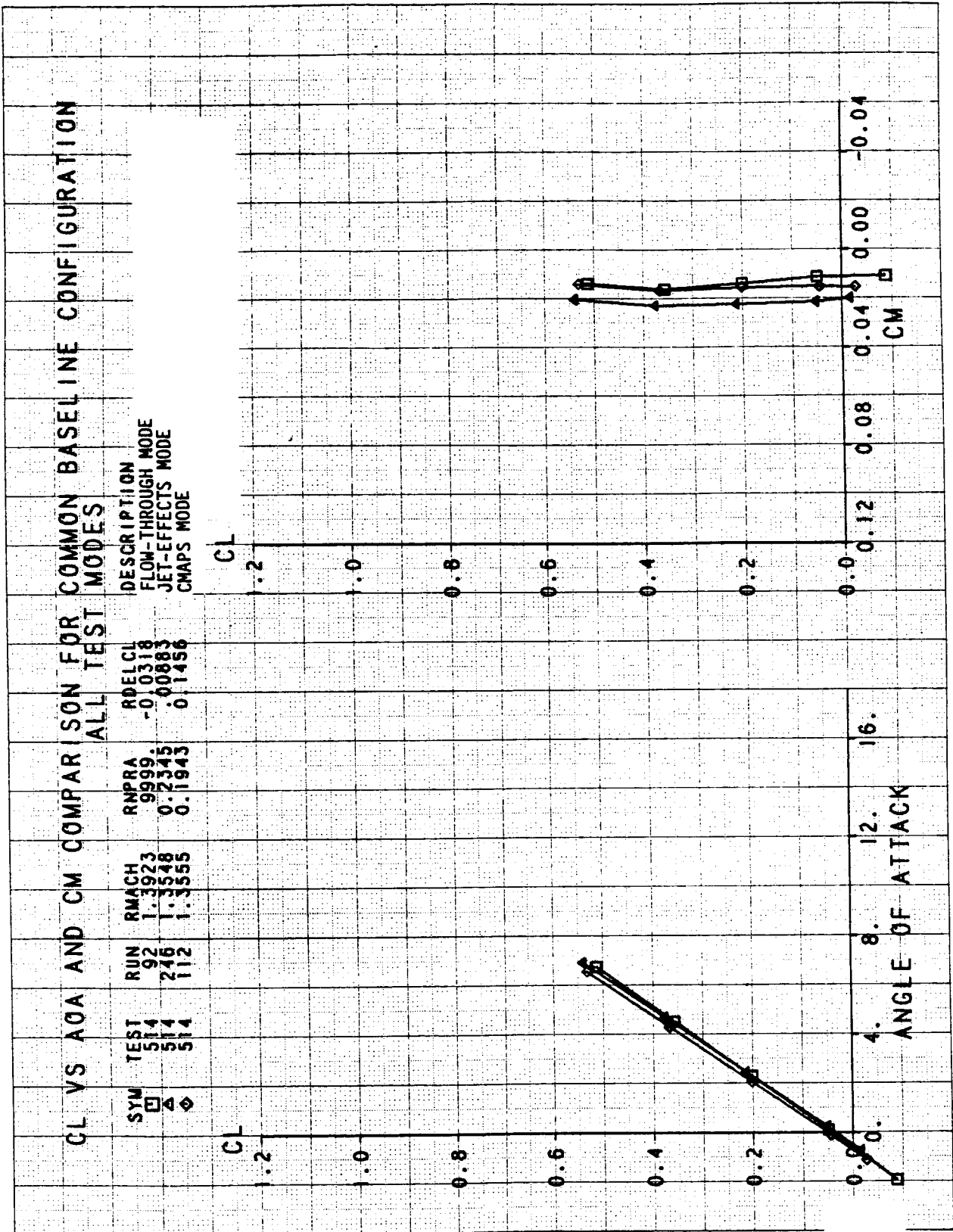
SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION	
▢	514	261	0.9016	-4.9704	JET-EFFECTS	MODE:0 DEG VECTOR ALBEN A/B
▲	514	266	0.9028	-5.0740	JET-EFFECTS	MODE:20 DEG VECTOR ALBEN A/B

ALPHA = 0°

230

THRUST VECTORING EFFECT ON CL, CD AND CM VS NPR
JET-EFFECTS MODE WITH A/B ALBEN

THRUST VECTORING EFFECT ON NOZZLE FORCE AND MOMENT DATA
JET-EFFECTS MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
▢	514	251	1.1933	-0.0403	JET-EFFECTS MODE:0 DEG VECTOR ALBEN A/B
▲	514	283	1.1998	-0.0594	JET-EFFECTS MODE:20 DEG VECTOR ALBEN A/B

ALPHA = 0°

THRUST VECTORING EFFECT ON CL, CD AND CM VS NPR
JET-EFFECTS MODE WITH A/B ALBEN

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
□	514	251	1.1933	-0.0403	JET-EFFECTS MODE:0 DEG VECTOR ALBEN A/B
△	514	283	1.1998	-0.0594	JET-EFFECTS MODE:20 DEG VECTOR ALBEN A/B

0° ALPHA

POWER SETTING EFFECT ON NOZZLE FORCE AND MOMENT DATA
JET-EFFECTS MODE WITH ALBEN

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
▢	514	256	0.3973	-5.0527	JET-EFFECTS MODE;0 DEG VECTOR ALBEN A/B
▲	514	507	0.3978	-5.0003	JET-EFFECTS MODE;0 DEG VECTOR ALBEN DRY

0° ALPHA

CMNOZ

CDNOZ

CLNOZ

NOZZLE PRESSURE RATIO

POWER SETTING EFFECT ON CL, CD, AND CM VS NPR
JET-EFFECTS MODE WITH ALBEN

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
□	514	256	0.3973	-5.0527	JET-EFFECTS MODE 0 DEG VECTOR ALBEN A/B
△	514	307	0.3978	-5.0005	JET-EFFECTS MODE 0 DEG VECTOR ALBEN DRY

0° ALPHA

CM

CD

CL

NOZZLE PRESSURE RATIO

POWER SETTING EFFECT ON NOZZLE FORCE AND MOMENT DATA
JET-EFFECTS MODE WITH ALBEN

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
□	514	260	0.6012	-4.9908	JET-EFFECTS MODE;0 DEG VECTOR ALBEN A/B
△	514	310	0.6022	-5.0416	JET-EFFECTS MODE;0 DEG VECTOR ALBEN DRY

0° ALPHA

CLNOZ

CDNOZ

CMNOZ

NOZZLE PRESSURE RATIO

POWER SETTING EFFECT ON CL, CD, AND CM VS NPR
JET-EFFECTS MODE WITH ALBEN

237

POWER SETTING EFFECT ON NOZZLE FORCE AND MOMENT DATA
JET-EFFECTS MODE WITH ALBEN

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
□	514	261	0.9016	-4.9704	JET-EFFECTS MODE:0 DEG VECTOR ALBEN A/B
△	514	316	0.9009	-4.9113	JET-EFFECTS MODE:0 DEG VECTOR ALBEN DRY

ALPHA

0°

238

POWER SETTING EFFECT ON CL, CD, AND CM VS NPR
JET-EFFECTS MODE WITH ALBEN

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
□	514	261	0.9016	-4.9704	JET-EFFECTS MODE:0 DEG VECTOR ALBEN A/B
▲	514	316	0.9009	-4.9113	JET-EFFECTS MODE:0 DEG VECTOR ALBEN DRY

0° ALPHA

CANARD ROTATION EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
□	514	66	0.3993	5.0293	F/T,COMMON BASELINE
▲	514	67	0.3989	-0.0547	F/T,COMMON BASELINE
◇	514	68	0.3990	-5.0061	F/T,COMMON BASELINE
◉	514	69	0.3989	-10.026	F/T,COMMON BASELINE
✦	514	70	0.3990	-15.003	F/T,COMMON BASELINE
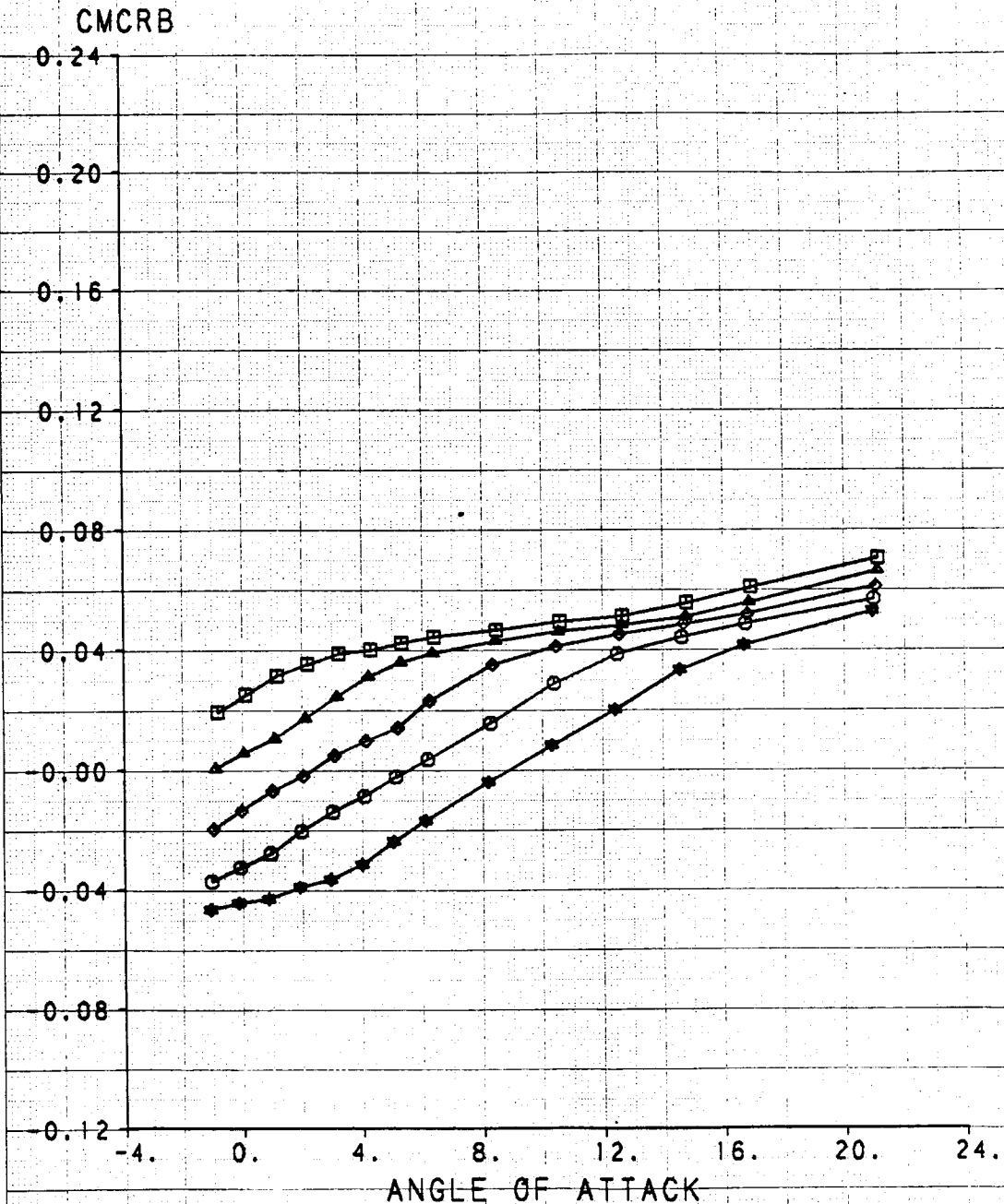
CMCRB

ANGLE OF ATTACK

CANARD ROTATION EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
□	514	75	0.6005	5.0269	F/T,COMMON BASELINE
▲	514	74	0.6008	0.0827	F/T,COMMON BASELINE
◆	514	73	0.5997	-5.0066	F/T,COMMON BASELINE
⊙	514	72	0.5996	-10.035	F/T,COMMON BASELINE
⬟	514	71	0.5986	-15.005	F/T,COMMON BASELINE

CMCRB

ANGLE OF ATTACK

CANARD ROTATION EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
□	514	77	0.9038	5.0182	F/T,COMMON BASELINE
▲	514	78	0.9010	-.00967	F/T,COMMON BASELINE
◇	514	79	0.9018	-5.0632	F/T,COMMON BASELINE
☉	514	80	0.9011	-10.049	F/T,COMMON BASELINE
✳	514	81	0.9022	-15.034	F/T,COMMON BASELINE
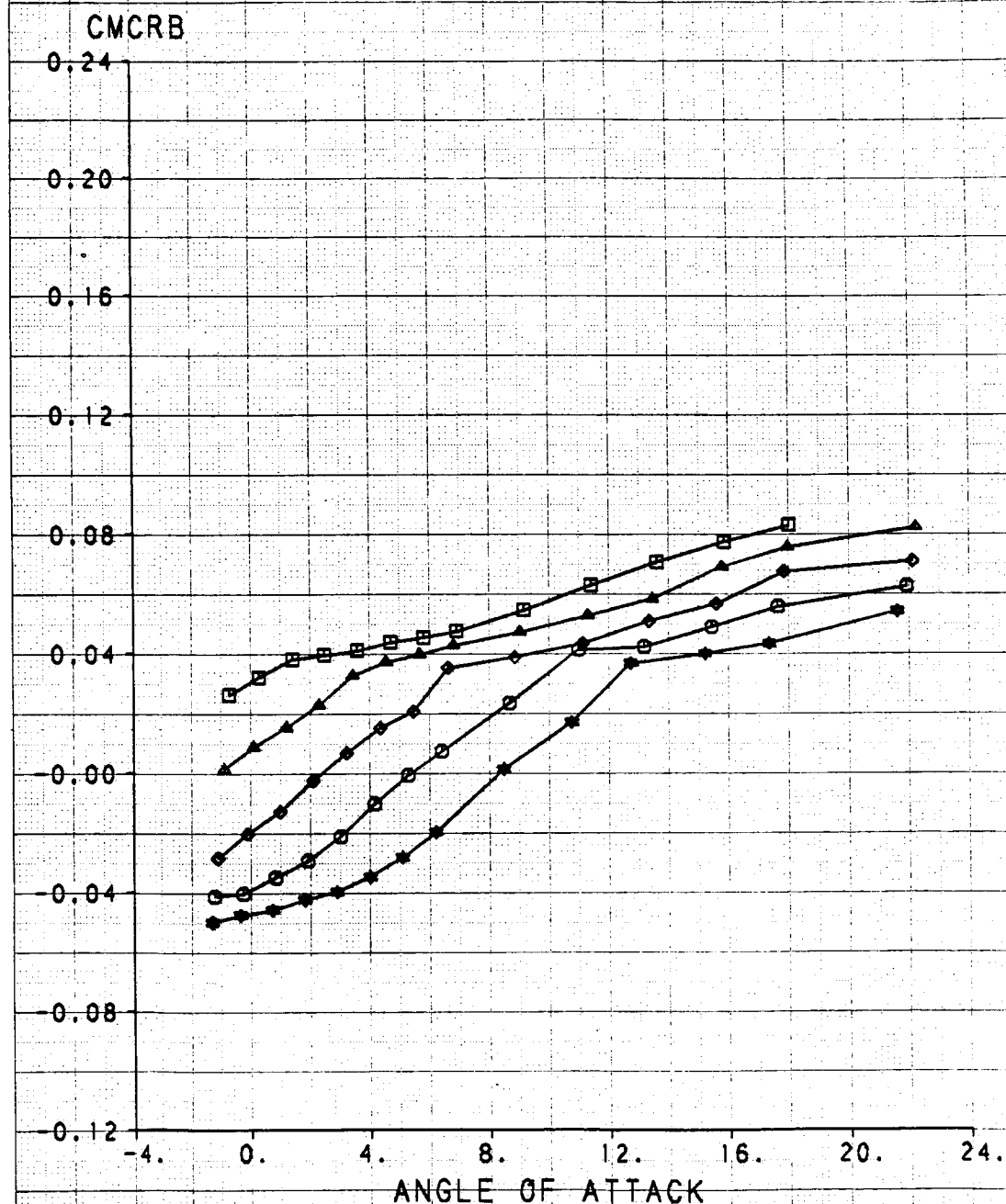
CMCRB vs ANGLE OF ATTACK

CANARD ROTATION EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
□	514	82	1.1884	5.0133	F/T, COMMON BASELINE
▲	514	85	1.1970	-0.0308	F/T, COMMON BASELINE
◇	514	86	1.1969	-5.0400	F/T, COMMON BASELINE
◉	514	87	1.1969	-10.025	F/T, COMMON BASELINE
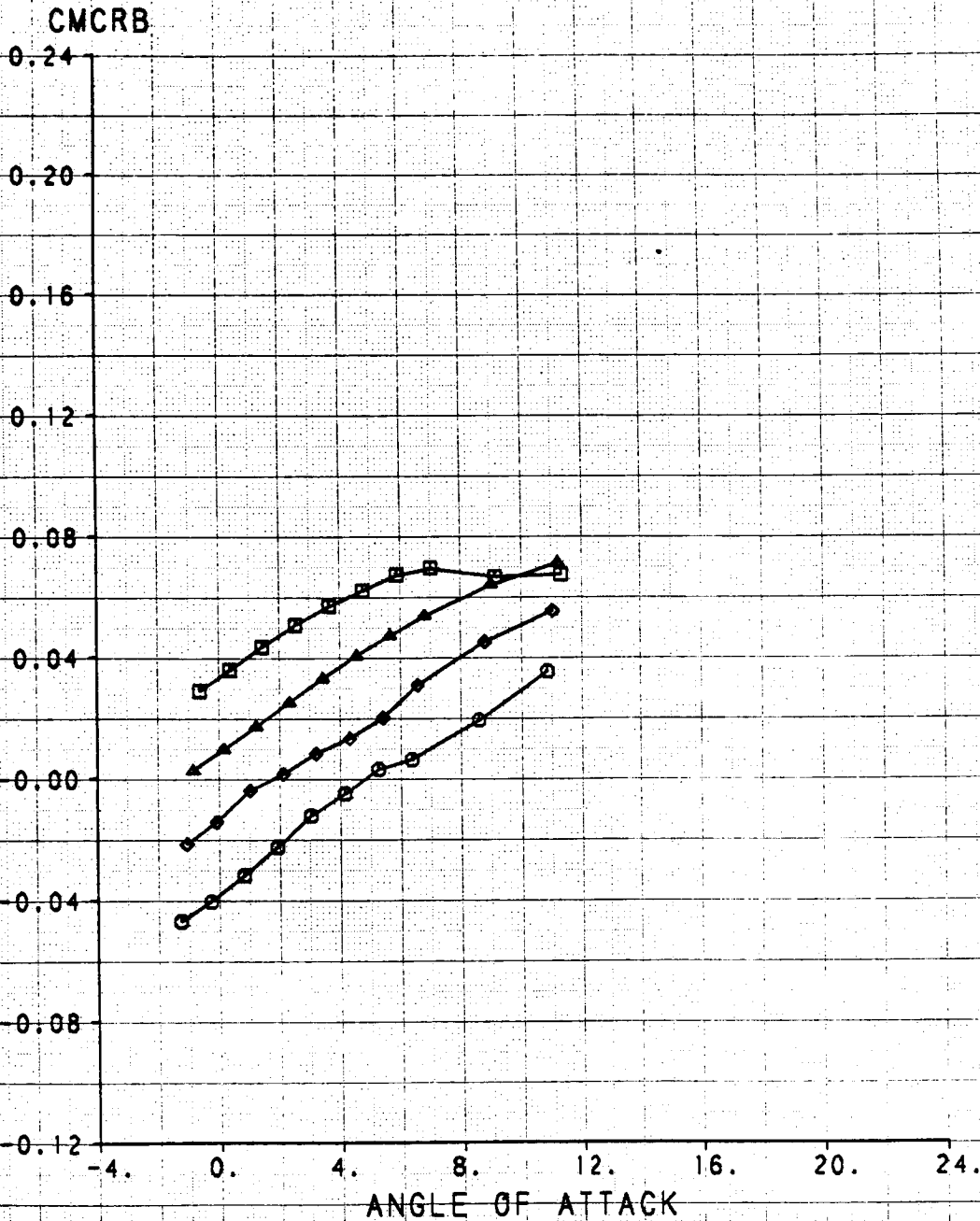
CMCRB

ANGLE OF ATTACK

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CANARD ROTATION EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	DESCRIPTION
▢	514	93	1.3899	5.1040	F/T, COMMON BASELINE
▲	514	92	1.3923	-0.0318	F/T, COMMON BASELINE
◇	514	94	1.3917	-4.9583	F/T, COMMON BASELINE
⊙	514	95	1.3908	-10.046	F/T, COMMON BASELINE

CANARD ROTATION EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	RMFR	DESCRIPTION
□	514	164	0.3896	5.0449	1.1079	F/T,NOZZLE EXTENSIONS W/EJECTORS
▲	514	165	0.3989	-0.0455	1.2024	F/T,NOZZLE EXTENSIONS W/EJECTORS
◆	514	167	9.4016	-4.9956	1.1343	F/T,NOZZLE EXTENSIONS W/EJECTORS
○	514	168	0.3985	-10.002	1.2163	F/T,NOZZLE EXTENSIONS W/EJECTORS
✦	514	169	0.3983	-15.006	1.2087	F/T,NOZZLE EXTENSIONS W/EJECTORS
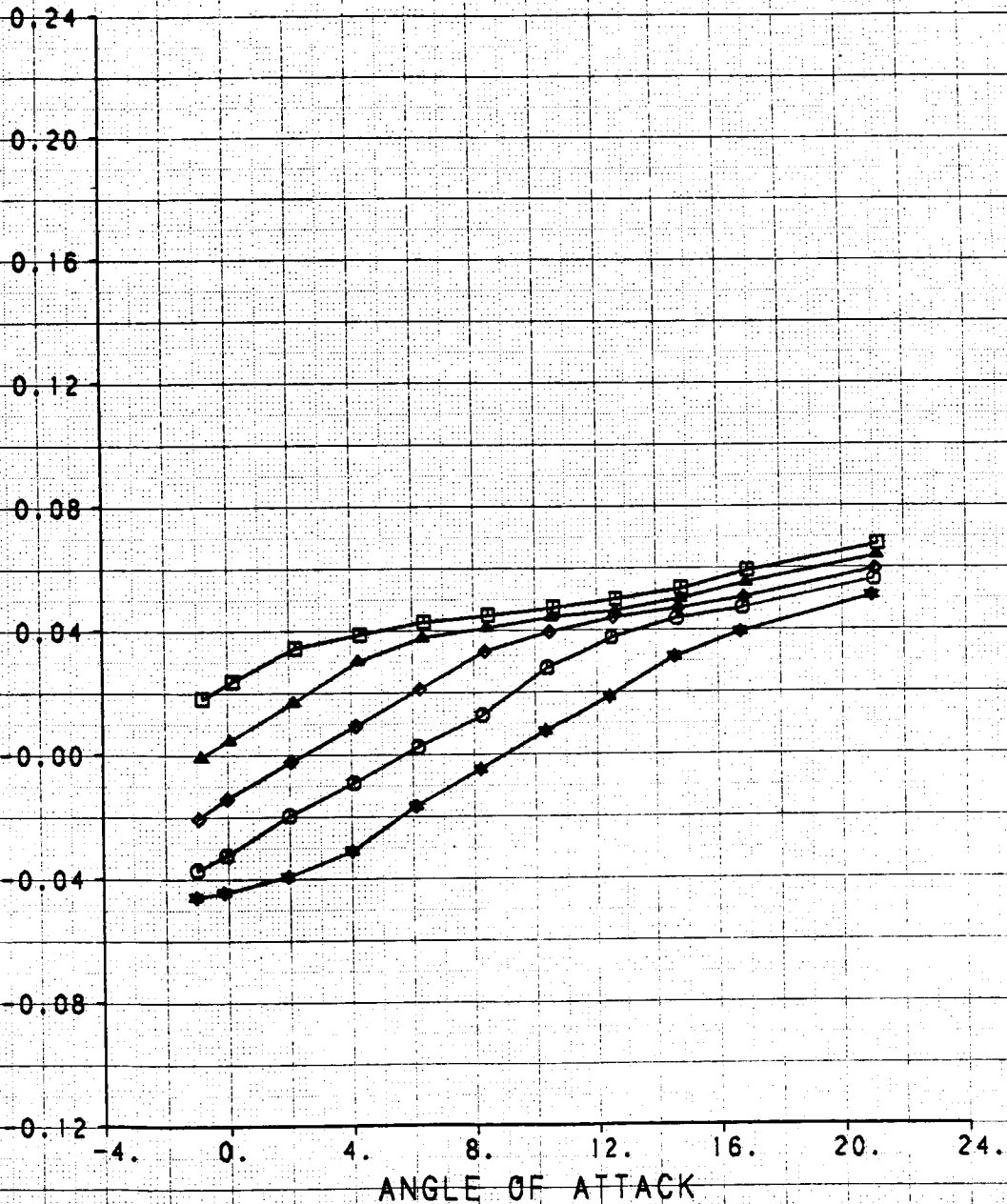
CMCRB vs ANGLE OF ATTACK

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CANARD ROTATION EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	RMFR	DESCRIPTION
□	514	173	0.5990	-0.0564	0.9221	F/T,NOZZLE EXTENSIONS W/EJECTORS
▲	514	172	0.5994	-4.9770	0.9207	F/T,NOZZLE EXTENSIONS W/EJECTORS
◆	514	171	0.5994	-10.014	0.9211	F/T,NOZZLE EXTENSIONS W/EJECTORS
○	514	170	0.6001	-14.987	0.9175	F/T,NOZZLE EXTENSIONS W/EJECTORS

CMCRB

ANGLE OF ATTACK

CANARD ROTATION EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	RMFR	DESCRIPTION
□	514	155	0.9018	-0.0601	0.8674	F/T,NOZZLE EXTENSIONS
▲	514	156	0.9022	-4.9921	0.8692	F/T,NOZZLE EXTENSIONS
◆	514	157	0.9020	-10.000	0.8674	F/T,NOZZLE EXTENSIONS
◎	514	158	0.9020	-15.025	0.8695	F/T,NOZZLE EXTENSIONS

CANARD ROTATION EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	RMFR	DESCRIPTION
□	514	180	1.1972	-0.0539	0.8895	F/T,NOZZLE EXTENSIONS
▲	514	159	1.1977	-4.9745	0.8895	F/T,NOZZLE EXTENSIONS

CMCRB

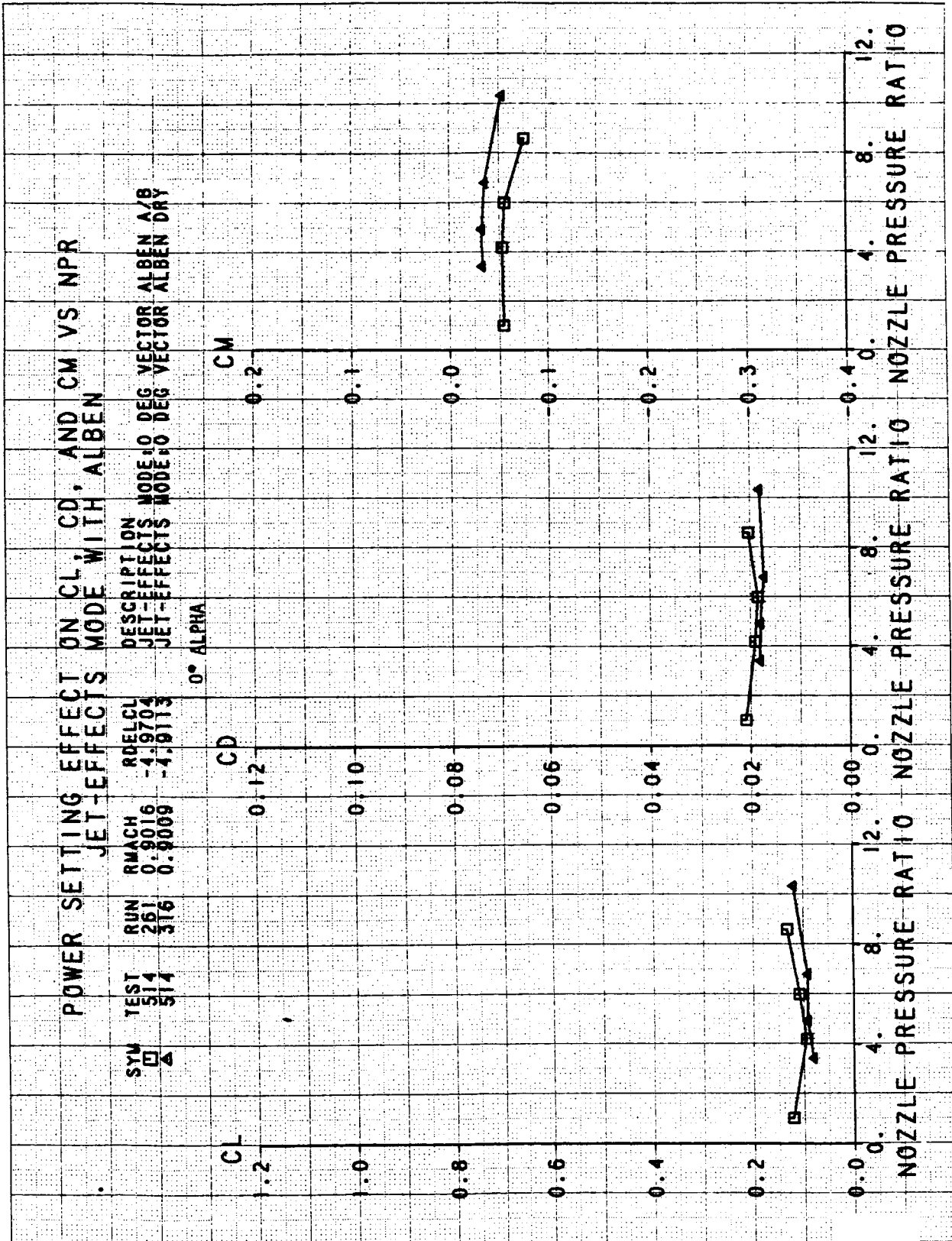ANGLE OF ATTACK

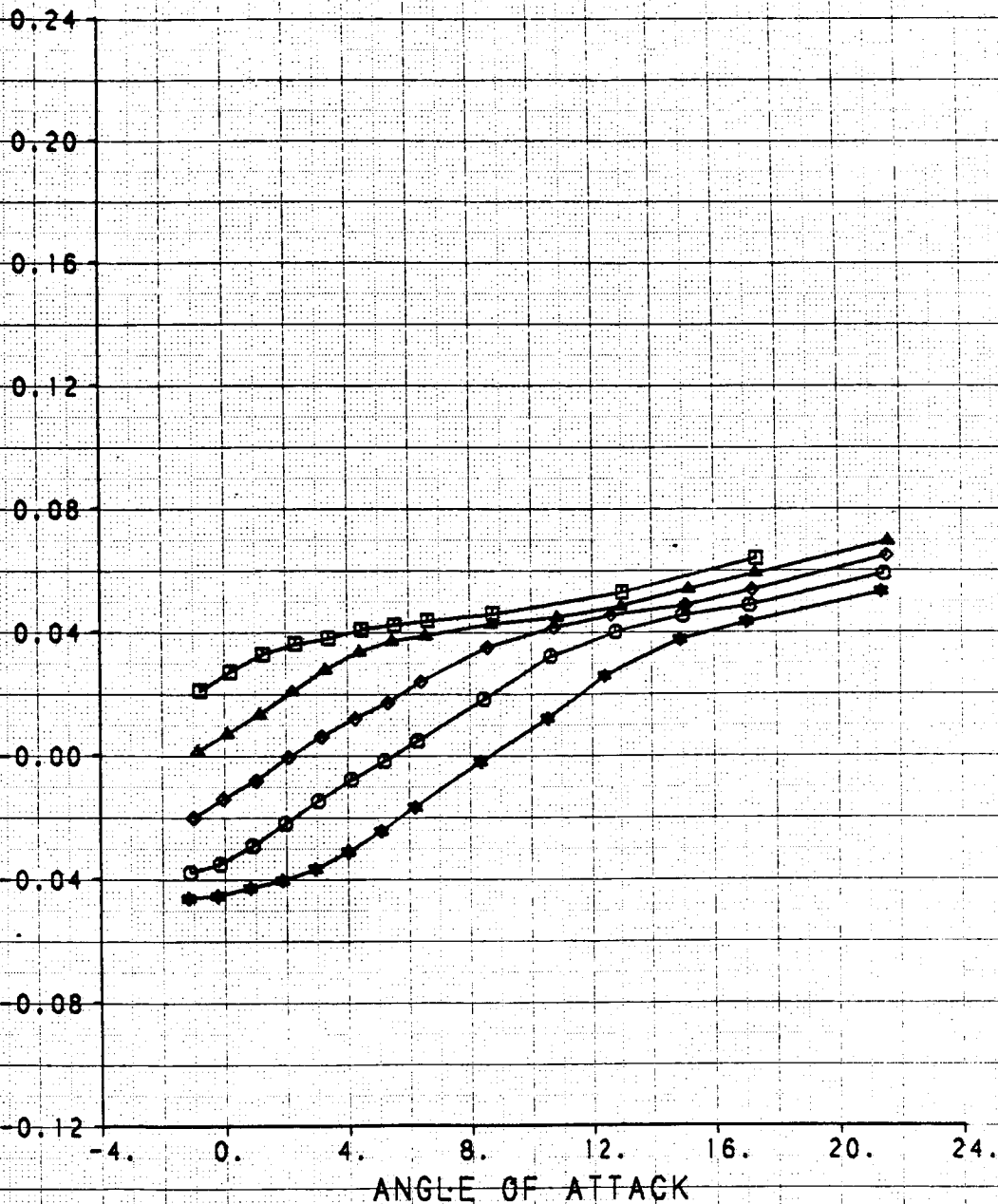## CANARD ROTATION EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	RMFR	DESCRIPTION
□	514	161	1.3936	-0.0567	0.9250	F/T,NOZZLE EXTENSIONS
▲	514	162	1.3939	-4.9931	0.9251	F/T,NOZZLE EXTENSIONS

CMCRB

ANGLE OF ATTACK

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CANARD ROTATION EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	RMFR	RNPRA	DESCRIPTION
□	514	277	0.4012	0.1416	1.1551	2.8538	CMAPS, SIMULATED AIRCRAFT
▲	514	288	0.4019	-5.0028	1.1505	2.8778	CMAPS, SIMULATED AIRCRAFT

CANARD ROTATION EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	RMFR	RNPRA	DESCRIPTION
▢	514	178	0.6009	0.1001	0.9161	3.8301	CMAPS, SIMULATED AIRCRAFT
▲	514	179	0.6010	-4.9809	0.9158	3.8557	CMAPS, SIMULATED AIRCRAFT
◇	514	180	0.6010	-10.081	0.9169	3.8478	CMAPS, SIMULATED AIRCRAFT
◉	514	182	0.5994	-14.883	0.9215	3.8168	CMAPS, SIMULATED AIRCRAFT
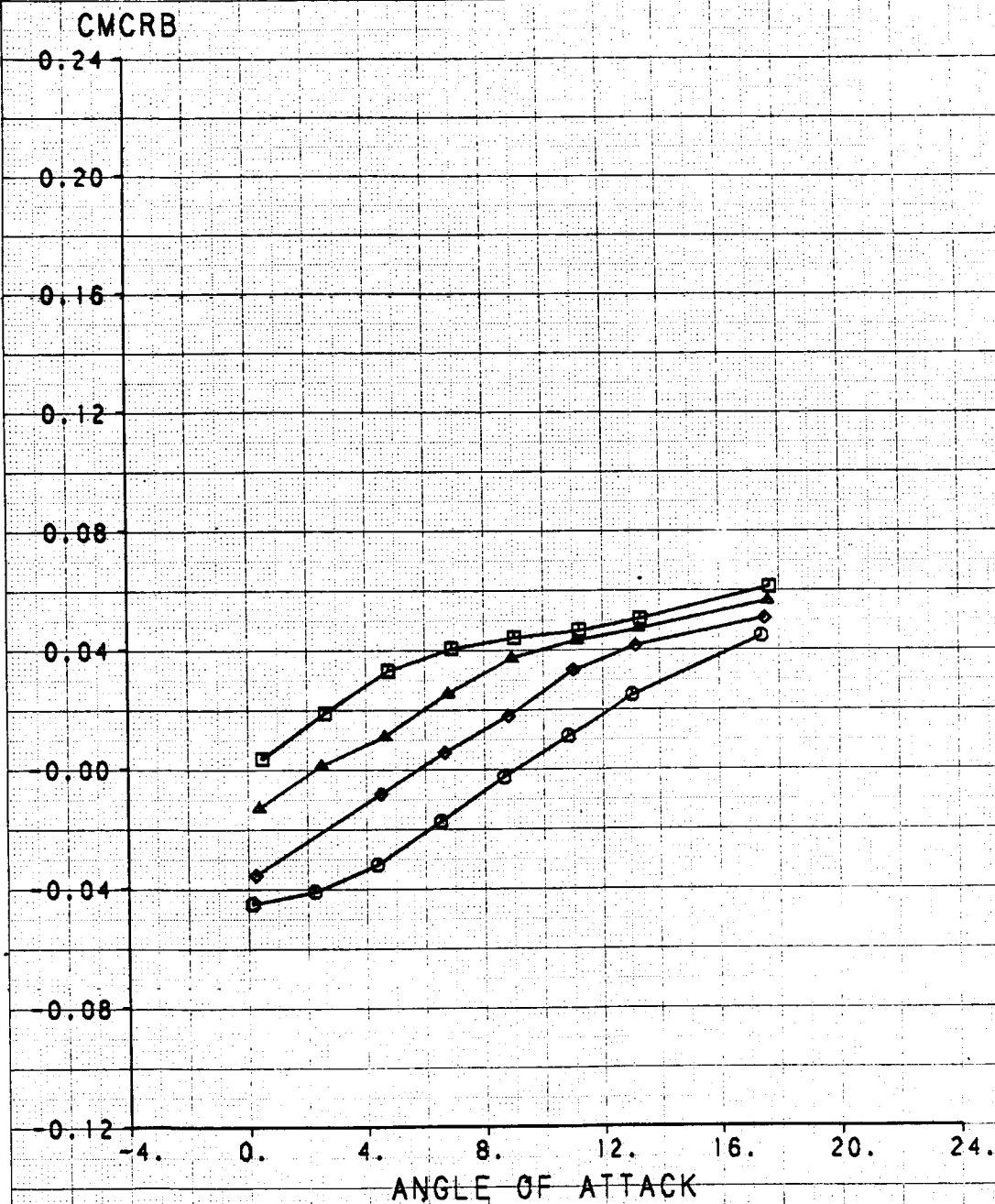
CMCRB vs ANGLE OF ATTACK

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CANARD ROTATION EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	RMFR	RNPRA	DESCRIPTION
□	514	197	0.9031	0.0791	0.7501	5.4208	CMAPS, SIMULATED AIRCRAFT
▲	514	215	0.8964	-4.9625	0.7534	5.3011	CMAPS, SIMULATED AIRCRAFT
◇	514	231	0.9032	-10.143	0.7544	5.3161	CMAPS, SIMULATED AIRCRAFT
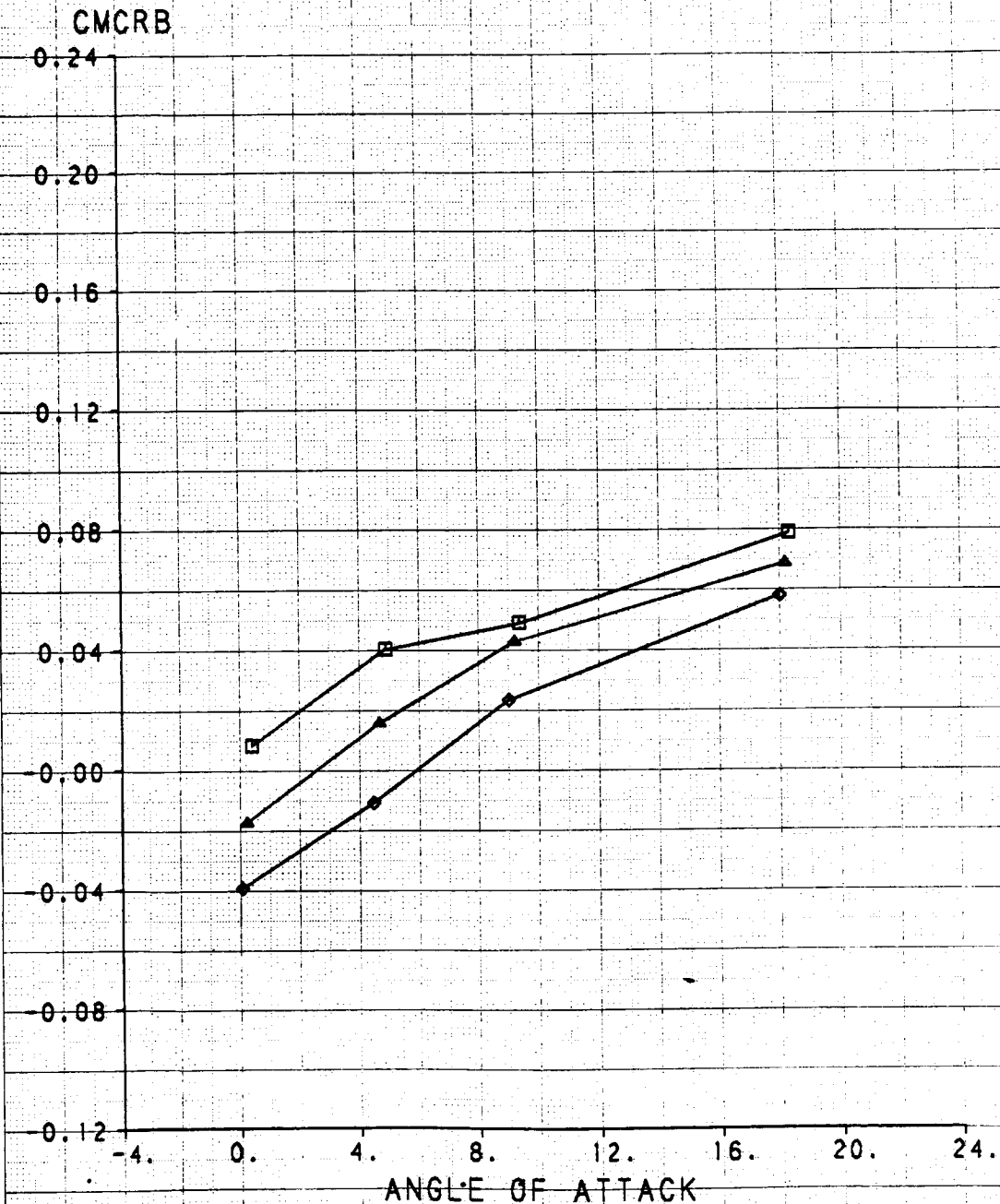

CMCRB vs ANGLE OF ATTACK

CANARD ROTATION EFFECTS ON CANARD ROOT BENDING MOMENT

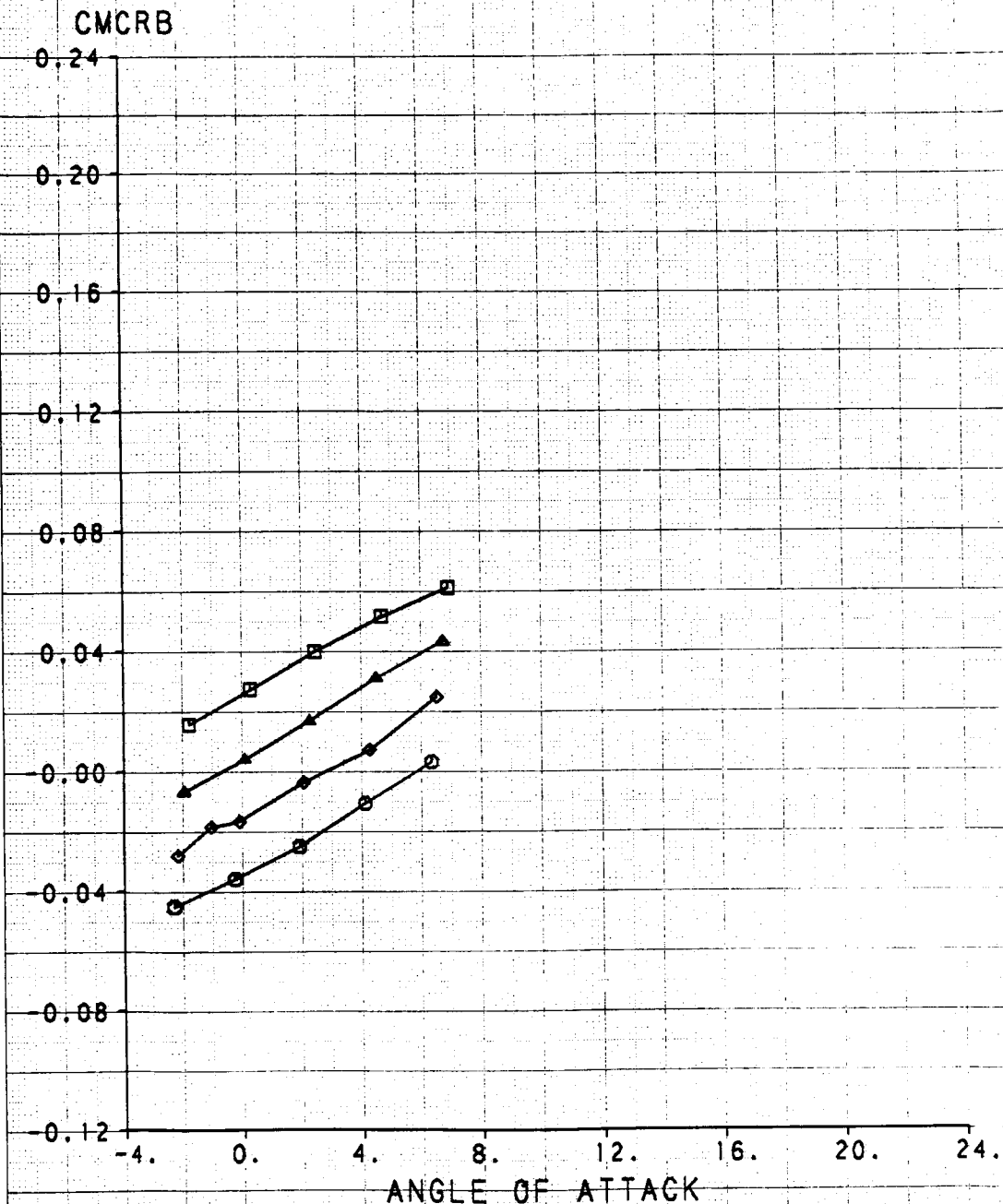| SYM	TEST	RUN	RMACH	RDELCL	RMFR	RNPRA	DESCRIPTION
▢	514	242	1.1906	0.1042	0.7579	7.5840	CMAPS,SIMULATED AIRCRAFT
▲	514	249	1.1920	-5.0946	0.7579	7.5379	CMAPS,SIMULATED AIRCRAFT

CMCRB vs ANGLE OF ATTACK

CANARD ROTATION EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	RMFR	RNPRA	DESCRIPTION
□	514	256	1.3969	0.1083	0.7929	9.5970	CMAPS, SIMULATED AIRCRAFT
▲	514	263	1.3970	-5.0666	0.7915	9.6047	CMAPS, SIMULATED AIRCRAFT

CMCRB

ANGLE OF ATTACK

MASS FLOW RATIO EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	RMFR	DESCRIPTION
□	514	188	0.3999	-4.9989	0.5546	F/T,NOZZLE EXTENSIONS W/EJECTORS
▲	514	206	0.3982	-4.9948	0.8216	F/T,NOZZLE EXTENSIONS W/EJECTORS
◆	514	178	0.3986	-4.9726	1.1164	F/T,NOZZLE EXTENSIONS W/EJECTORS
⊙	514	167	0.4016	-4.9956	1.1343	F/T,NOZZLE EXTENSIONS W/EJECTORS

CMCRB vs ANGLE OF ATTACK

MASS FLOW RATIO EFFECTS ON CANARD ROOT BENDING MOMENT
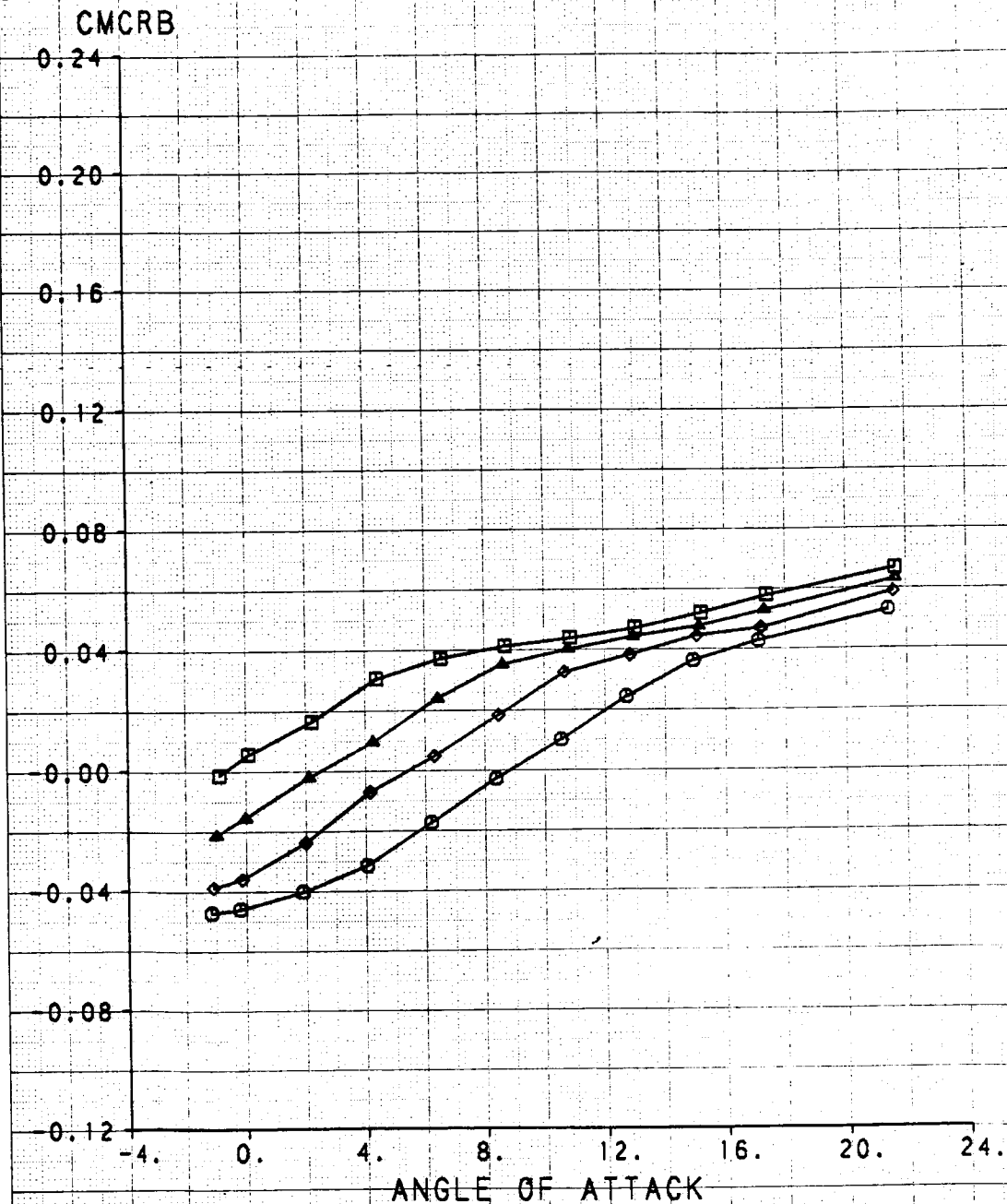
SYM	TEST	RUN	RMACH	RDELCL	RMFR	DESCRIPTION
▢	514	193	0.5980	-4.9926	0.4112	F/T,NOZZLE EXTENSIONS W/EJECTORS
▲	514	211	0.5992	-4.9896	0.6102	F/T,NOZZLE EXTENSIONS W/EJECTORS
◆	514	182	0.5987	-4.9870	0.8311	F/T,NOZZLE EXTENSIONS W/EJECTORS
◉	514	172	0.5994	-4.9770	0.9207	F/T,NOZZLE EXTENSIONS W/EJECTORS

CMCRB

ANGLE OF ATTACK

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MASS FLOW RATIO EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	RMFR	DESCRIPTION
□	514	117	0.9000	-4.9149	0.3485	F/T,NOZZLE EXTENSIONS
▲	514	133	0.9018	-4.9635	0.5176	F/T,NOZZLE EXTENSIONS
◆	514	147	0.9018	-4.9854	0.7063	F/T,NOZZLE EXTENSIONS
◐	514	156	0.9022	-4.9921	0.8692	F/T,NOZZLE EXTENSIONS

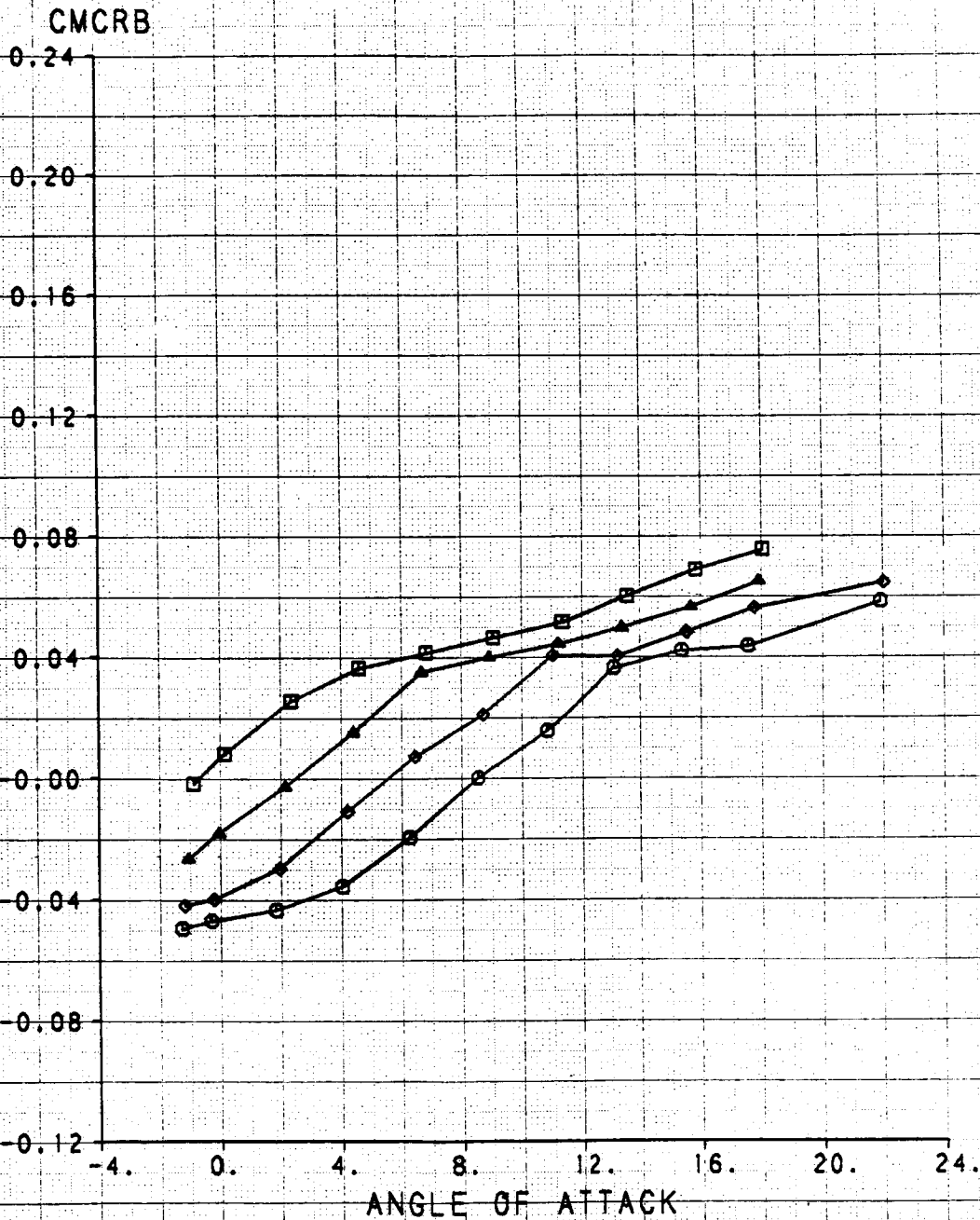# MASS FLOW RATIO EFFECTS ON CANARD ROOT BENDING MOMENT

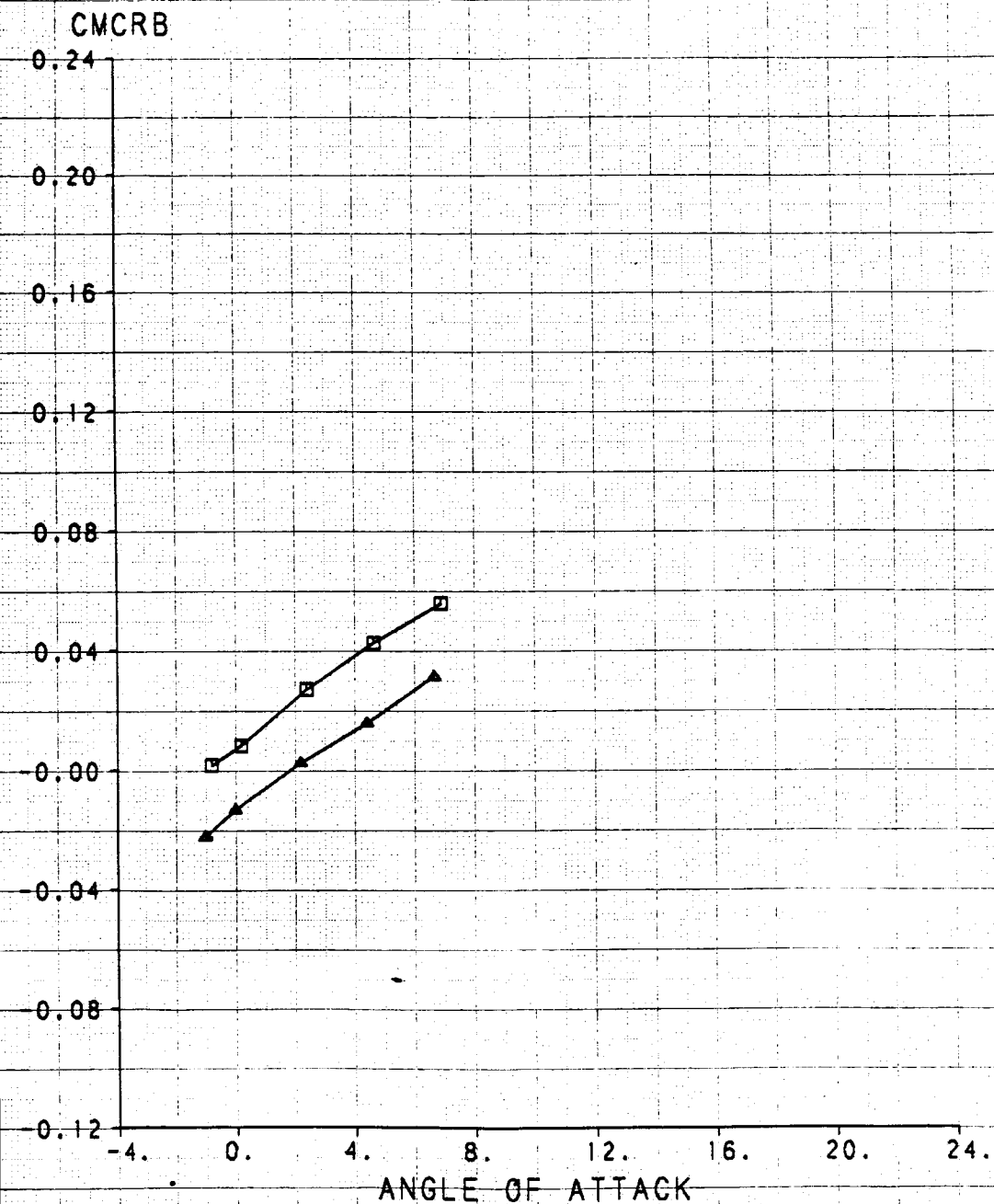| SYM	TEST	RUN	RMACH	RDELCL	RMFR	DESCRIPTION
□	514	121	1.1999	-0.0575	0.3523	F/T,NOZZLE EXTENSIONS
▲	514	129	1.1991	-0.0409	0.5236	F/T,NOZZLE EXTENSIONS
◆	514	145	1.1963	-0.0861	0.7123	F/T,NOZZLE EXTENSIONS
○	514	160	1.1972	-0.0539	0.8895	F/T,NOZZLE EXTENSIONS

CMCRB vs ANGLE OF ATTACK

MASS FLOW RATIO EFFECTS ON CANARD ROOT BENDING MOMENT

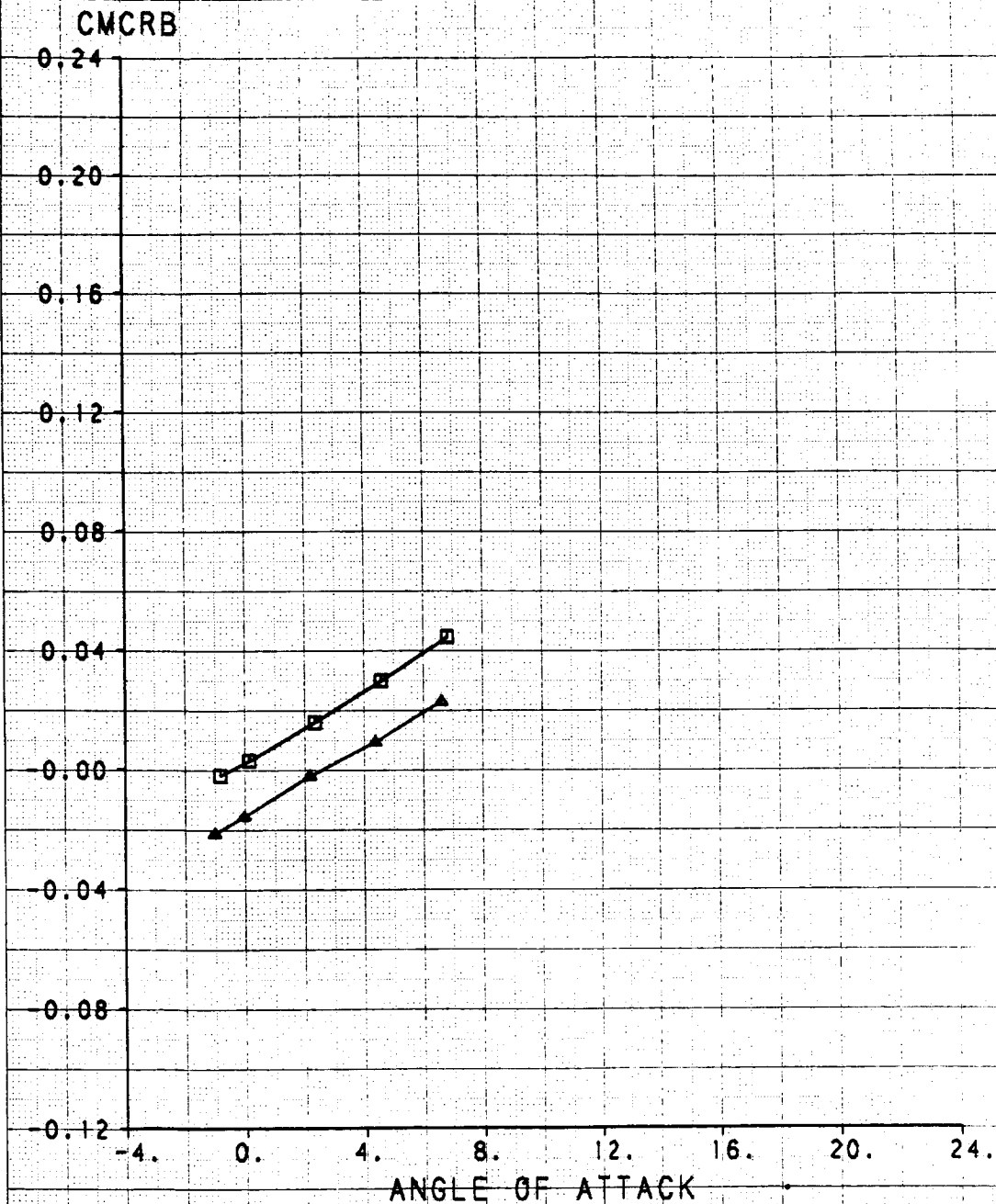| SYM	TEST	RUN	RMACH	RDELCL	RMFR	DESCRIPTION
□	514	124	1.3871	-.00406	0.3654	F/T,NOZZLE EXTENSIONS
▲	514	128	1.3948	-0.0234	0.5445	F/T,NOZZLE EXTENSIONS
◆	514	142	1.3972	-0.0567	0.7423	F/T,NOZZLE EXTENSIONS
○	514	161	1.3938	-0.0567	0.9250	F/T,NOZZLE EXTENSIONS
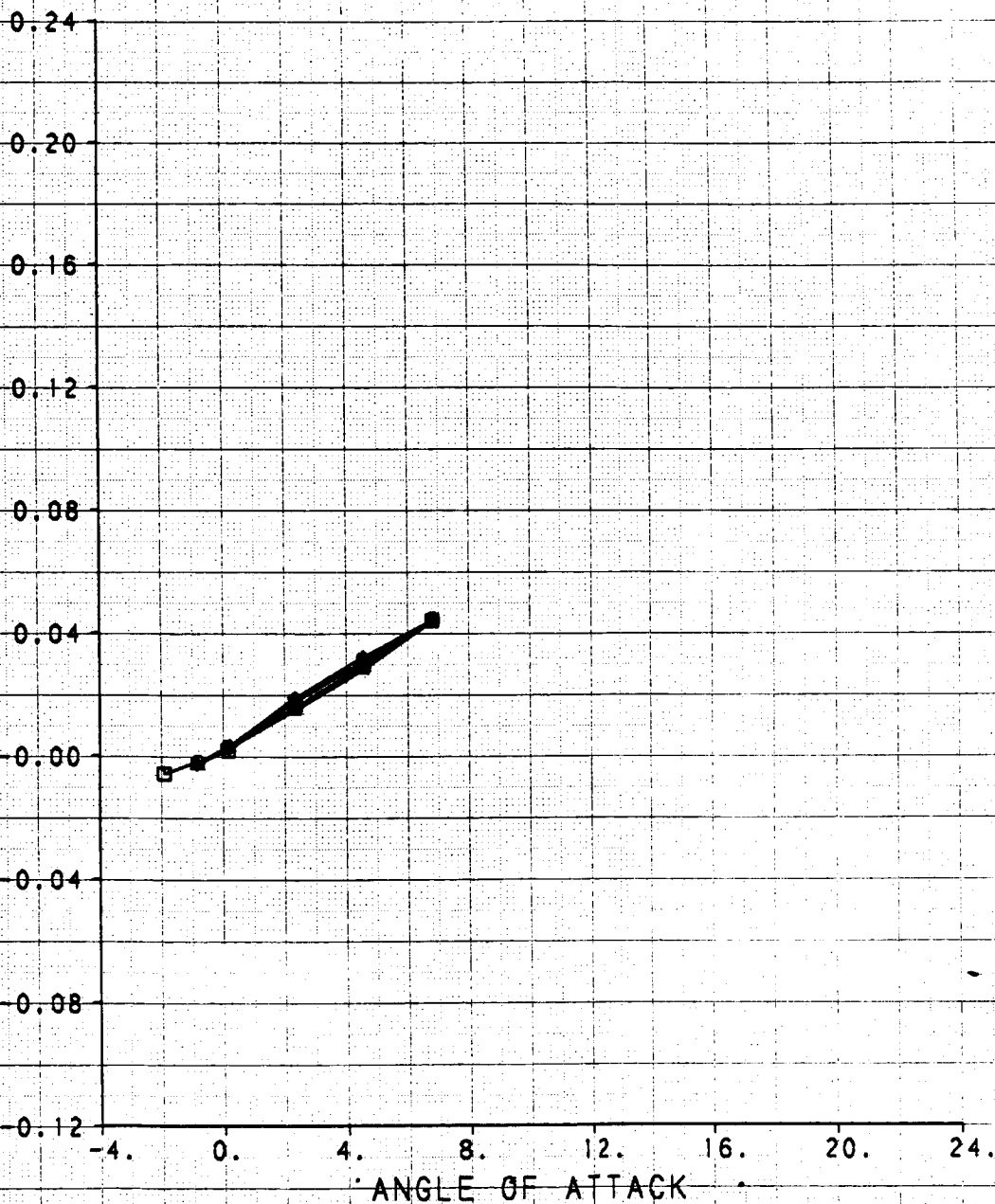
CMCRB vs ANGLE OF ATTACK

MASS FLOW RATIO EFFECTS ON CANARD ROOT BENDING MOMENT

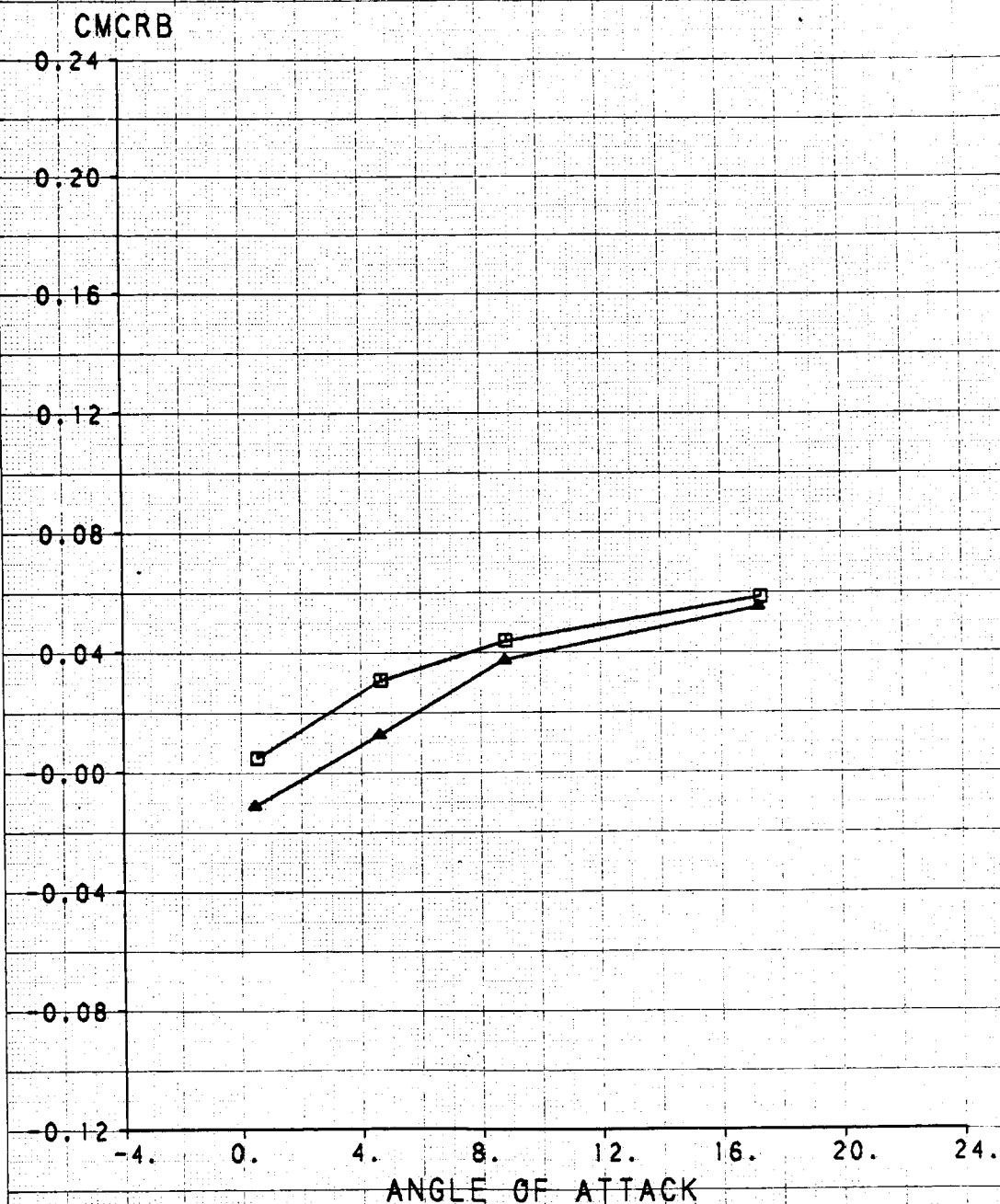| SYM	TEST	RUN	RMACH	RDELCL	RMFR	RNPRA	DESCRIPTION
□	514	265	0.4019	0.1531	0.7801	1.3322	CMAPS,SIMULATED AIRCRAFT
▲	514	266	0.4019	0.1562	0.9176	1.3145	CMAPS,SIMULATED AIRCRAFT
◇	514	260	0.4023	0.1520	1.0552	1.2816	CMAPS,SIMULATED AIRCRAFT
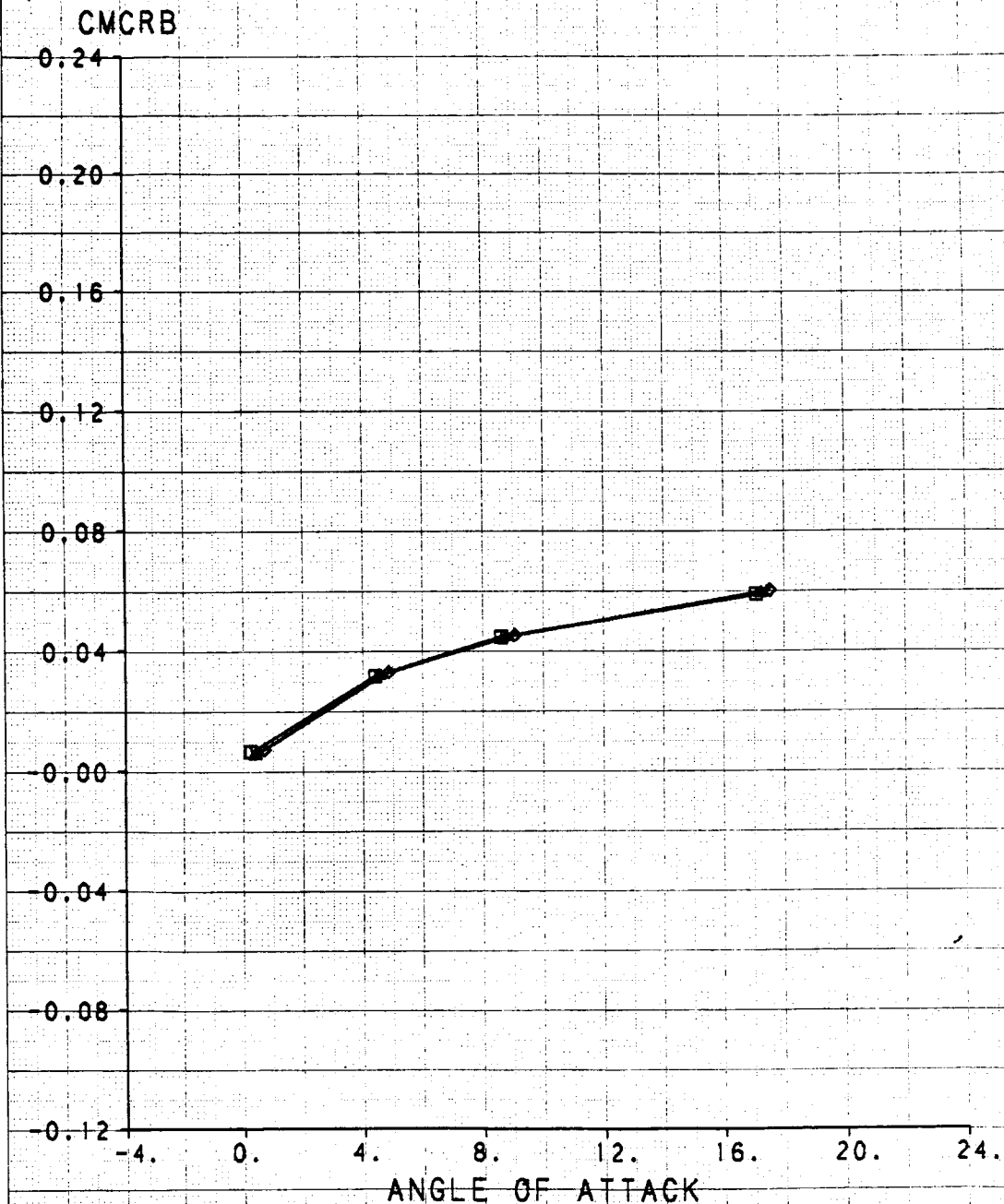
CMCRB

ANGLE OF ATTACK

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MASS FLOW RATIO EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	RMFR	RNPRA	DESCRIPTION
□	514	192	0.9021	0.1239	0.6751	4.4266	CMAPS, SIMULATED AIRCRAFT
▲	514	198	0.9042	0.0938	0.7568	4.3951	CMAPS, SIMULATED AIRCRAFT
◇	514	200	0.9052	0.1250	0.8685	4.2850	CMAPS, SIMULATED AIRCRAFT
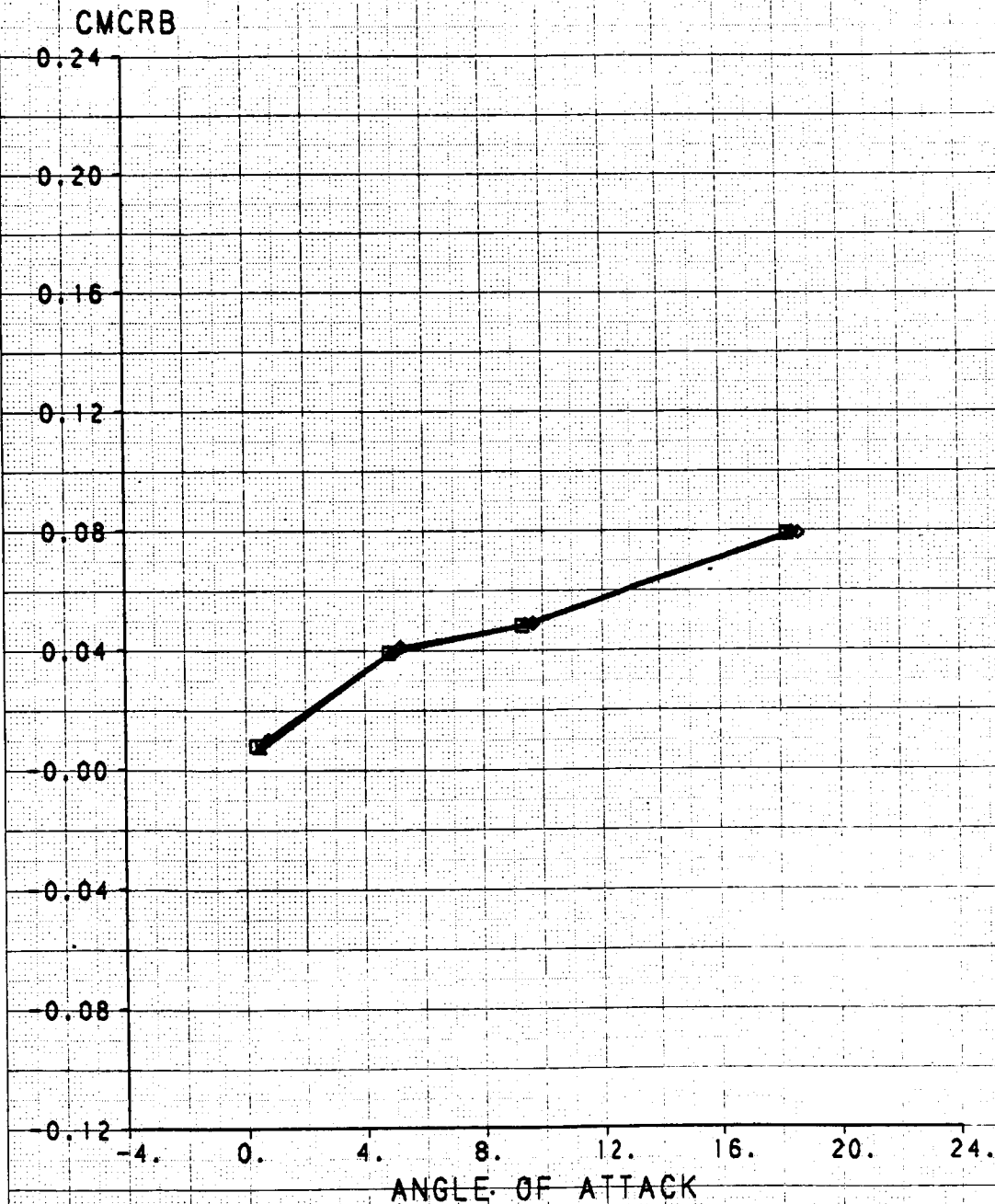
# NOZZLE PRESSURE RATIO EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	RNPRA	DESCRIPTION
□	514	238	0.3989	-4.9629	0.0637	J/E,COMMON BASELINE JET-OFF
▲	514	258	0.3992	-5.0064	4.0334	J/E,COMMON BASELINE JET-ON
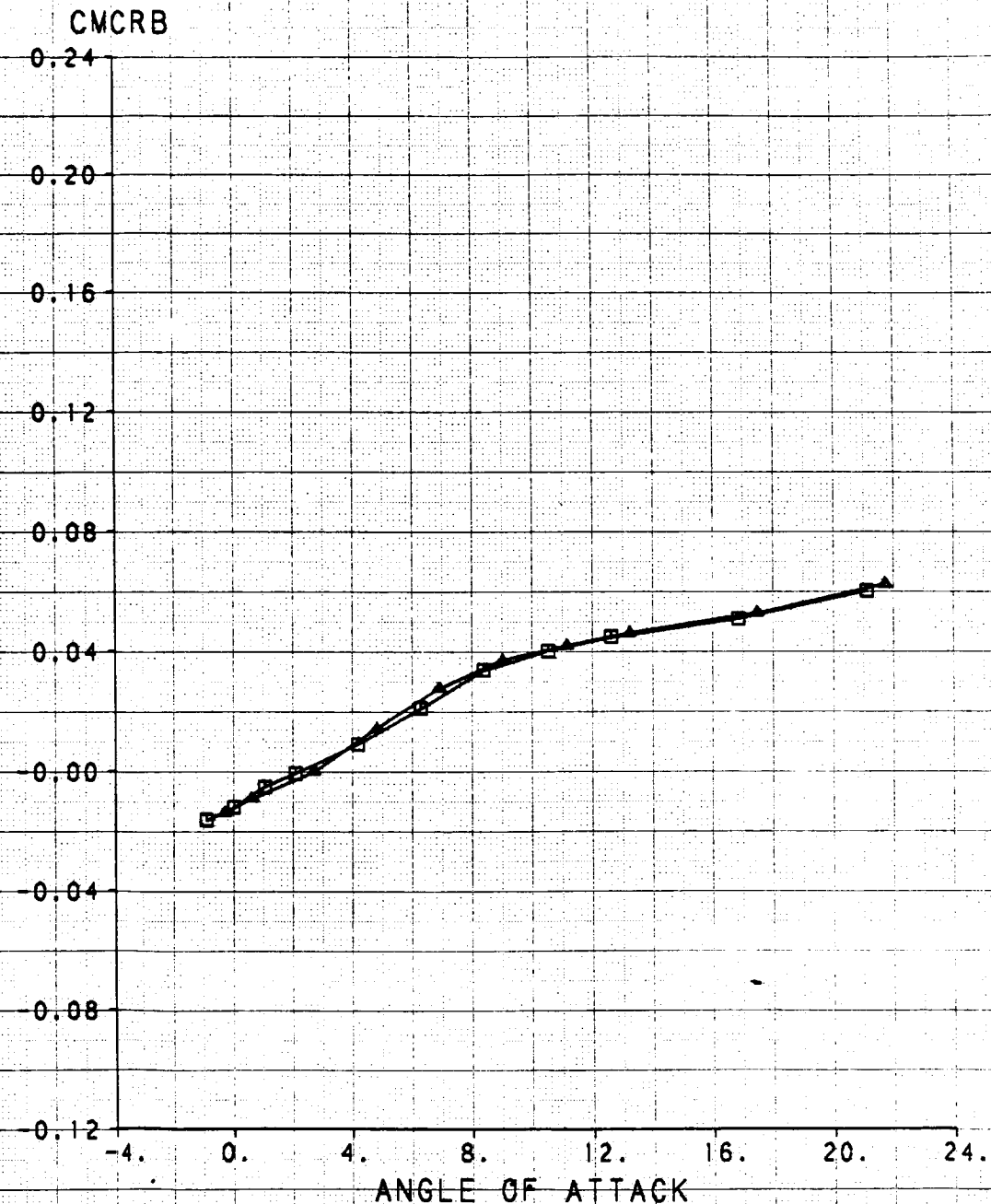
CMCRB

ANGLE OF ATTACK

NOZZLE PRESSURE RATIO EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	RNPRA	DESCRIPTION
□	514	243	0.8214	-4.9911	0.0906	J/E,COMMON BASELINE JET-OFF
▲	514	259	0.8009	-4.9763	4.1996	J/E,COMMON BASELINE JET-ON

# NOZZLE PRESSURE RATIO EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	RNPRA	DESCRIPTION
⊡	514	244	0.9022	-4.9674	0.1384	J/E,COMMON BASELINE JET-OFF
▲	514	282	0.9019	-4.9891	6.0982	J/E,COMMON BASELINE JET-ON
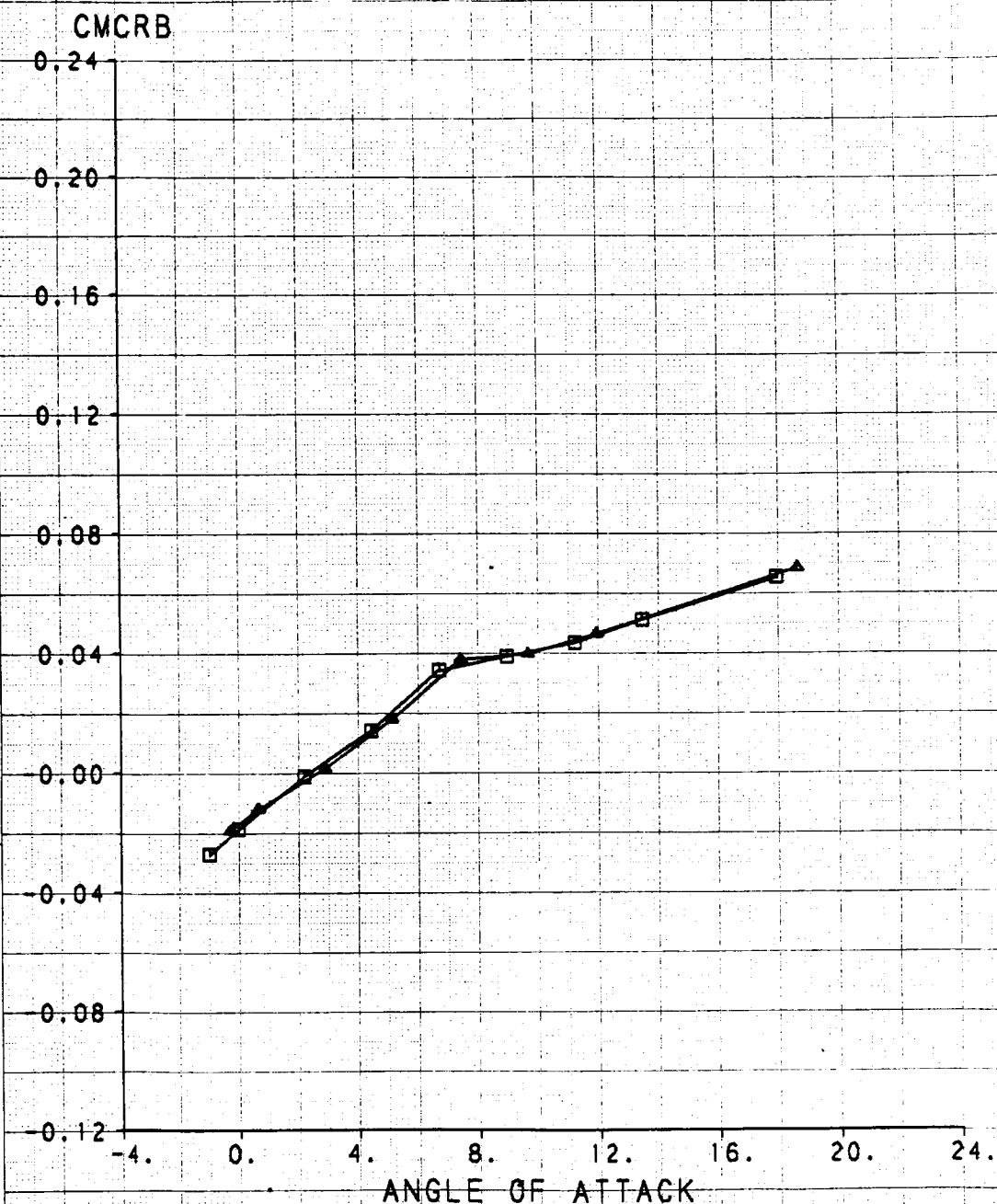
CMCRB

ANGLE OF ATTACK

NOZZLE PRESSURE RATIO EFFECTS ON CANARD ROOT BENDING MOMENT

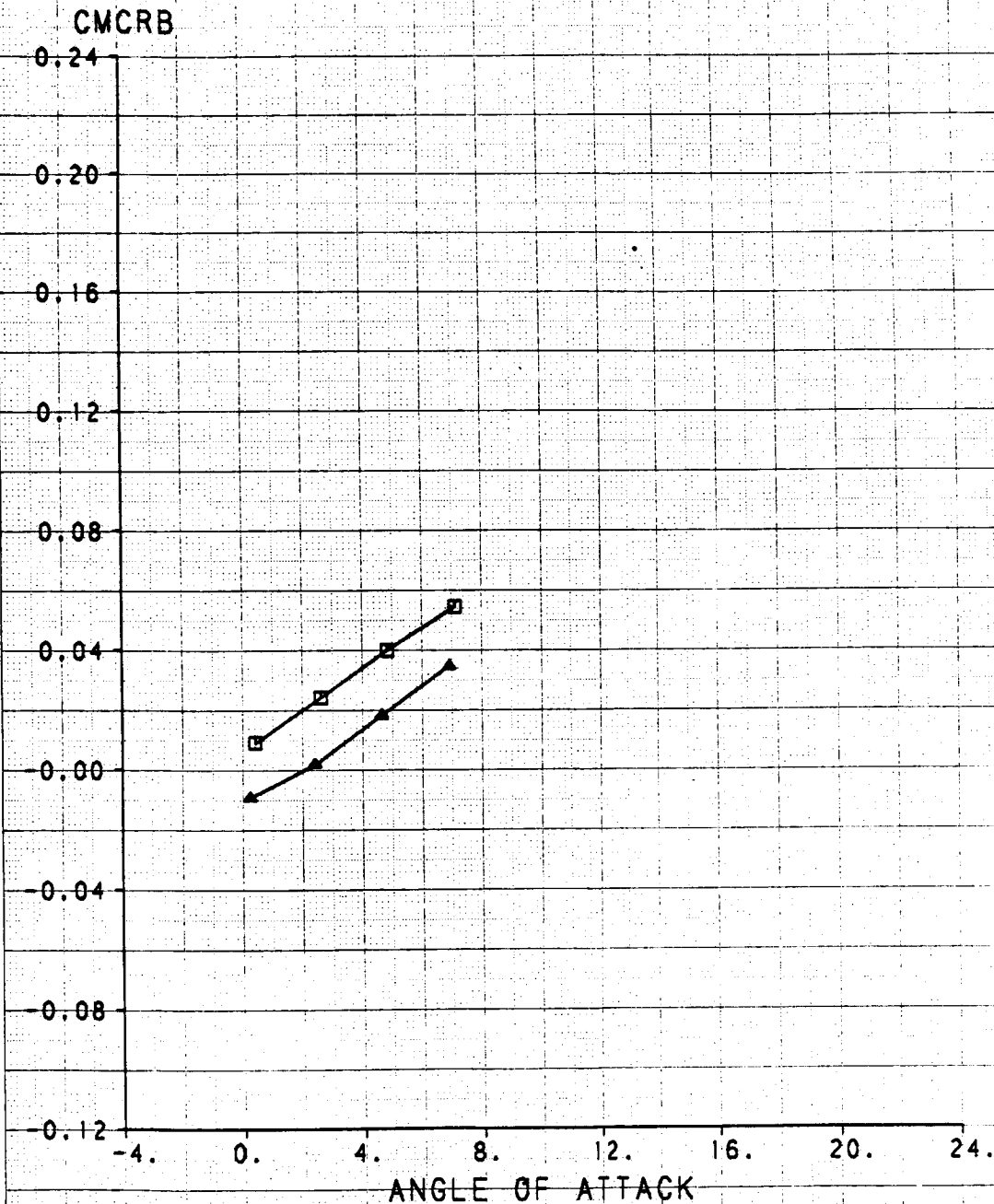| SYM	TEST	RUN	RMACH	RDELCL	RNPRA	DESCRIPTION
▢	514	245	1.1772	-0.1056	0.1893	J/E,COMMON BASELINE JET-OFF
▲	514	252	1.1846	-0.0448	9.0806	J/E,COMMON BASELINE JET-ON
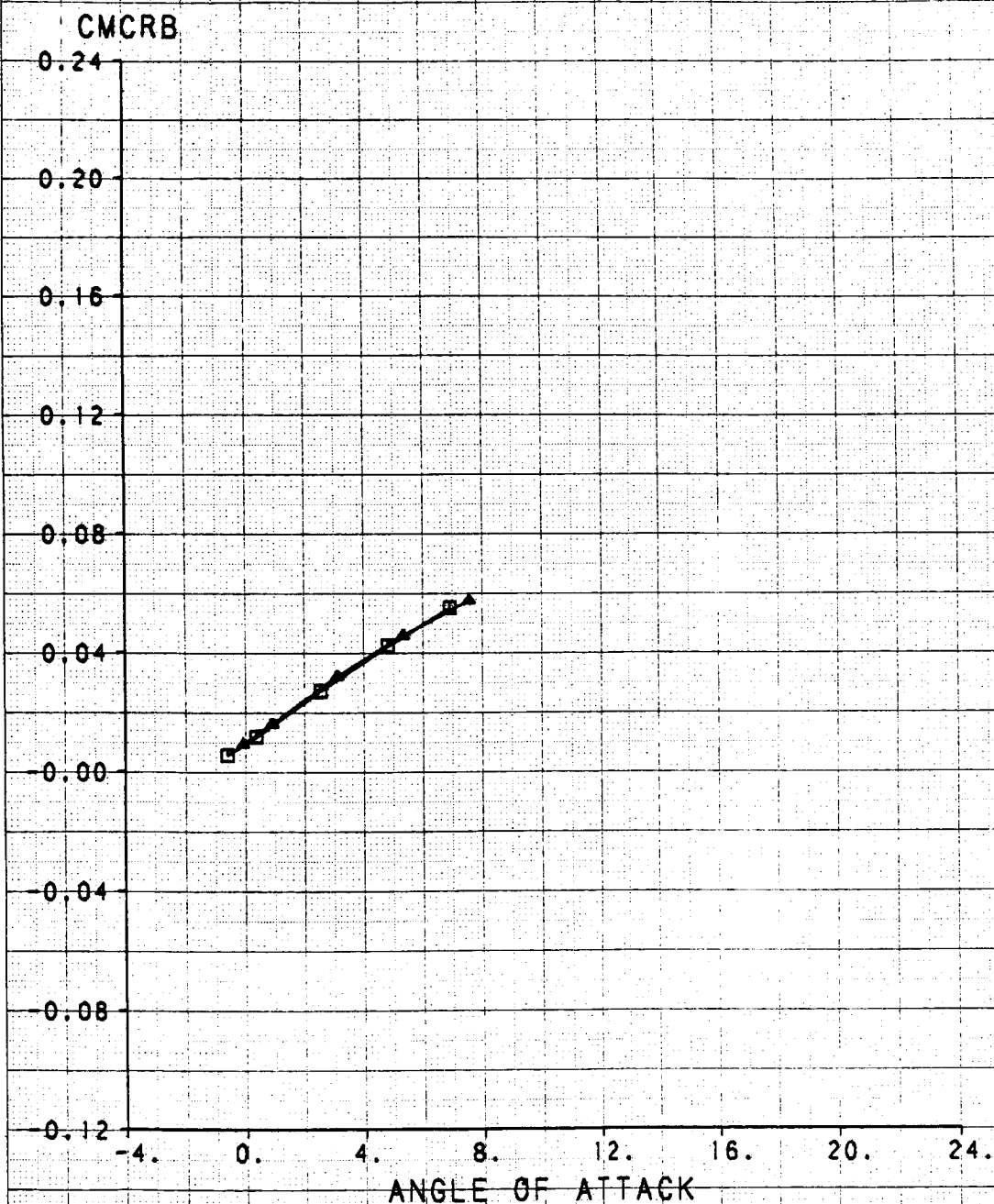
265

NOZZLE PRESSURE RATIO EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	RNPRA	DESCRIPTION
□	514	246	1.3548	.00883	0.2345	J/E,COMMON BASELINE JET-OFF
▲	514	254	1.3859	-0.0460	10.389	J/E,COMMON BASELINE JET-ON
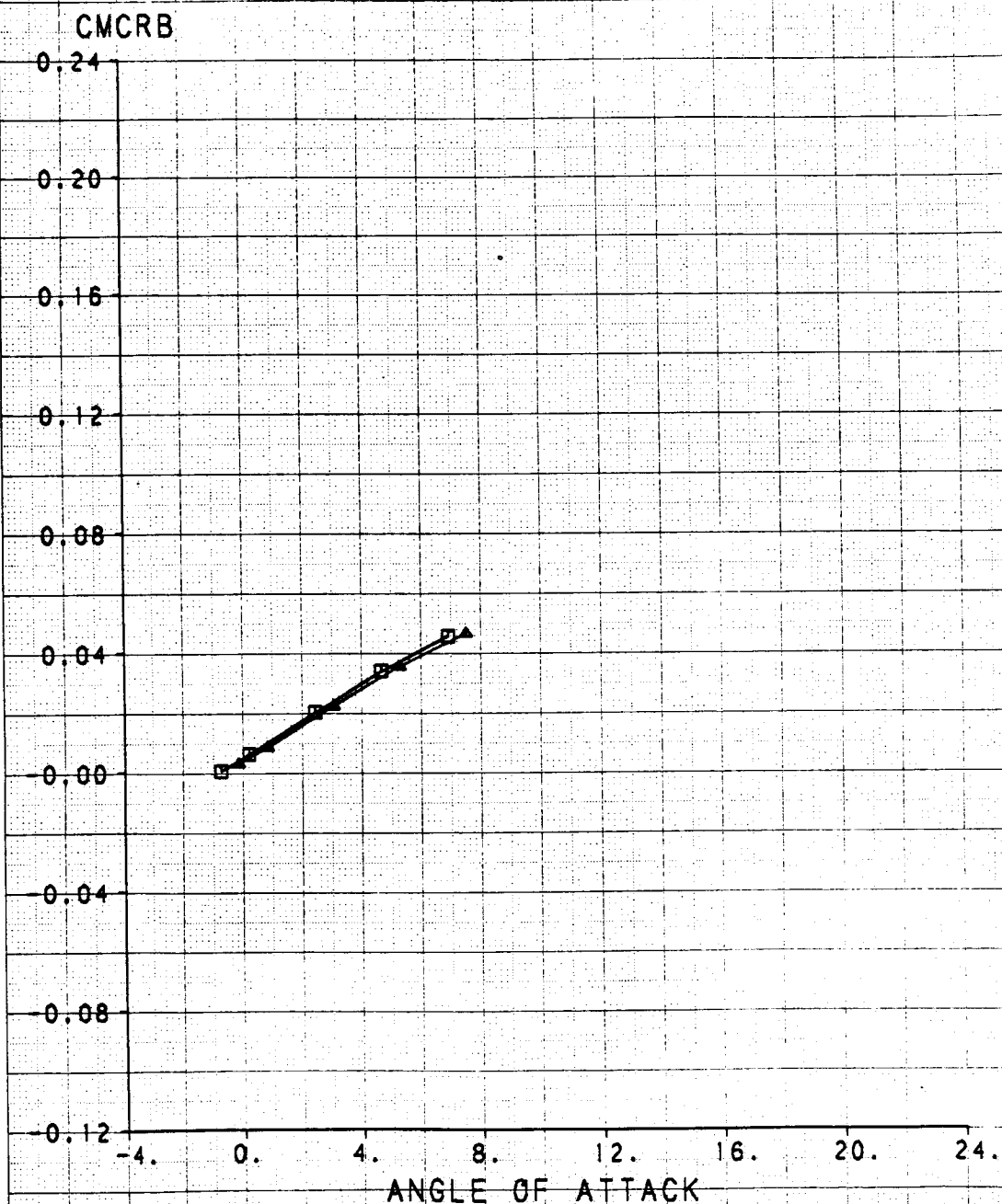
CMCRB

ANGLE OF ATTACK

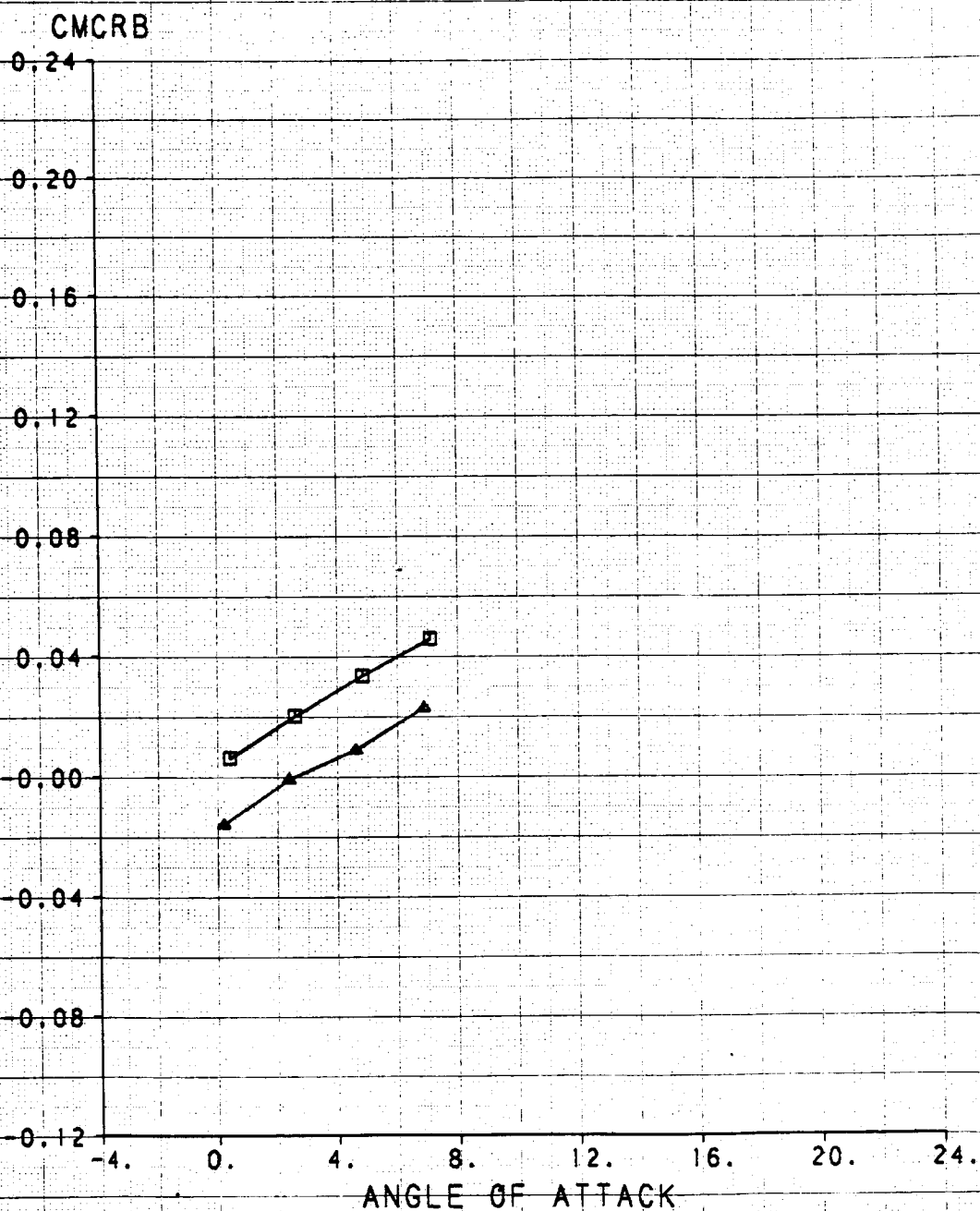## NOZZLE PRESSURE RATIO EFFECTS ON CANARD ROOT BENDING MOMENT

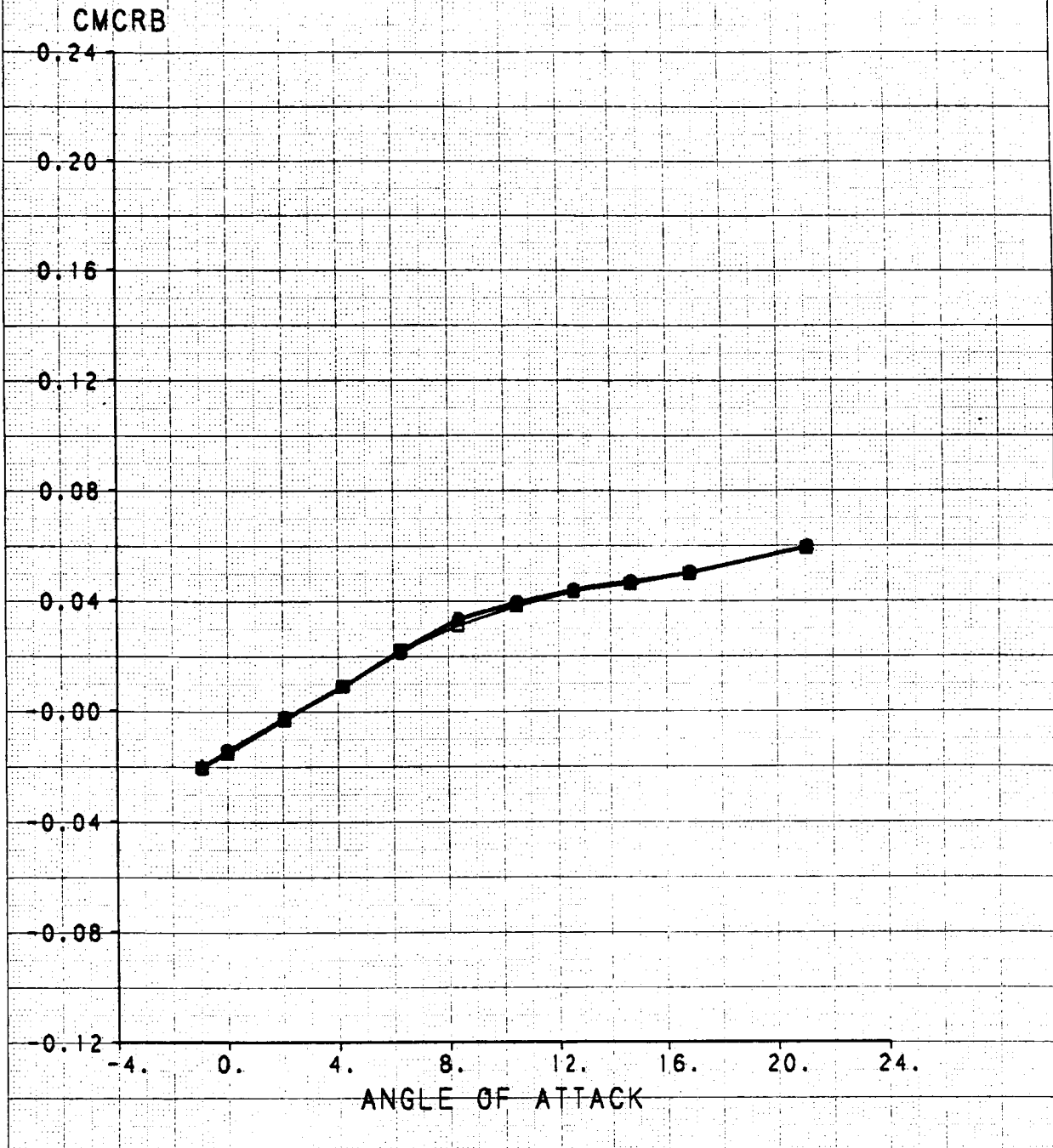| SYM	TEST	RUN	RMACH	ROELCL	RMFR	RNPRA	DESCRIPTION
☐	514	283	0.4017	-5.0039	1.1604	1.6483	CMAPS,SIMULATED AIRCRAFT
▲	514	284	0.4014	-5.0028	1.1603	1.9882	CMAPS,SIMULATED AIRCRAFT
◆	514	285	0.4019	-4.9983	1.1571	2.4178	CMAPS,SIMULATED AIRCRAFT
◎	514	288	0.4032	-5.0263	1.1353	3.3566	CMAPS,SIMULATED AIRCRAFT
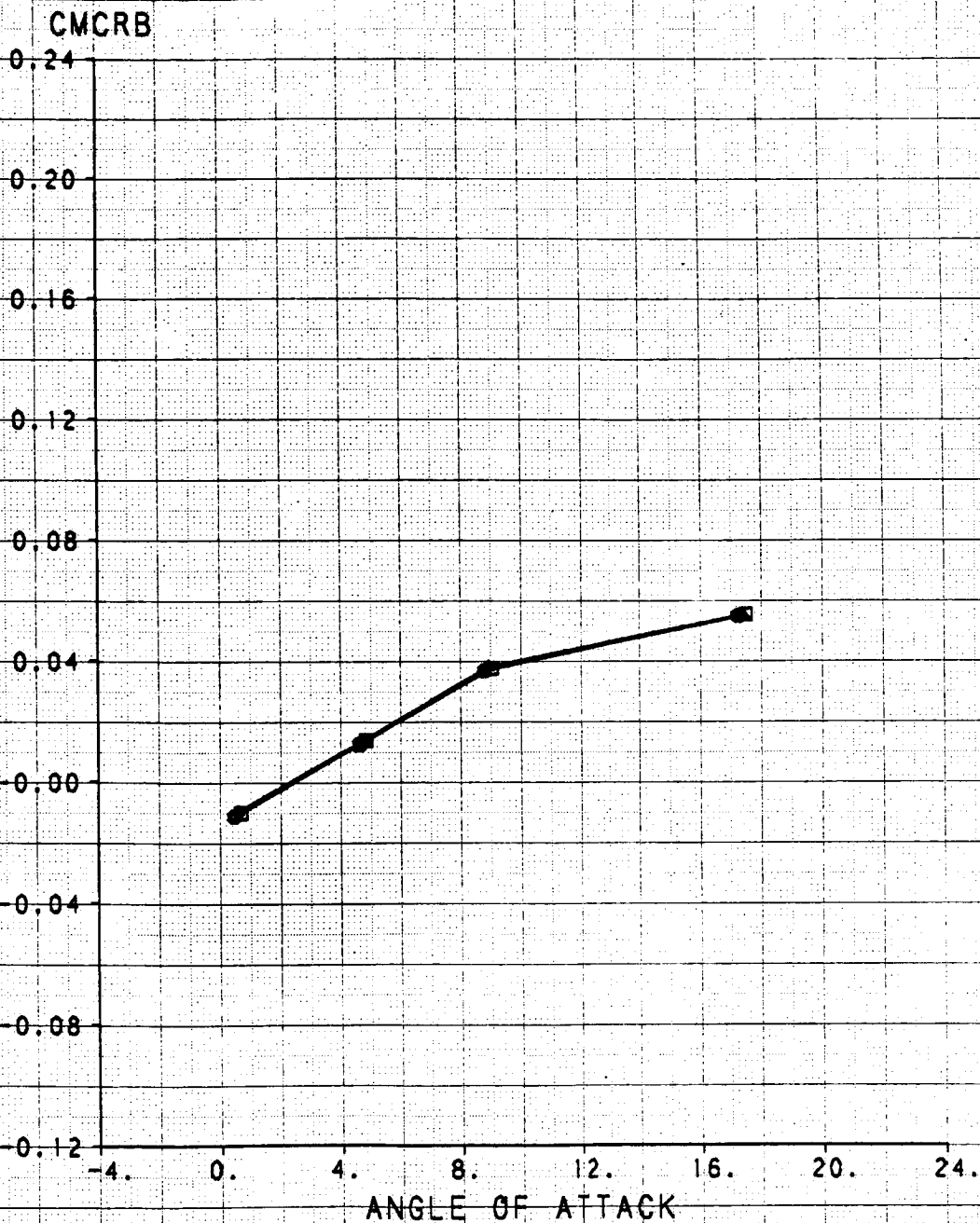
NOZZLE PRESSURE RATIO EFFECTS ON CANARD ROOT BENDING MOMENT

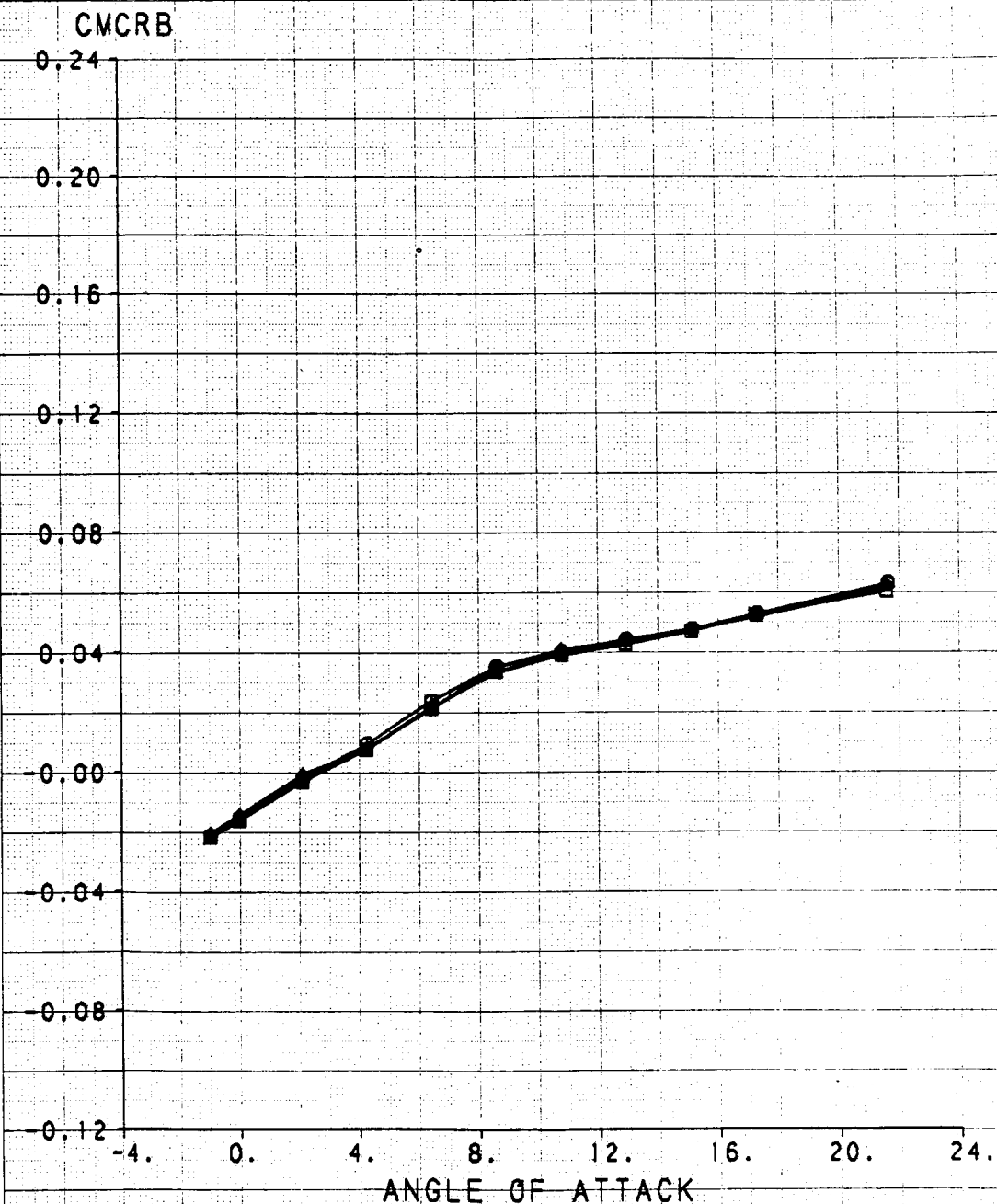| SYM	TEST	RUN	RMACH	RDELCL	RMFR	RNPRA	DESCRIPTION
□	514	175	0.5992	0.1480	0.9202	3.2903	CMAPS,SIMULATED AIRCRAFT
△	514	176	0.6009	0.1001	0.9161	3.8301	CMAPS,SIMULATED AIRCRAFT
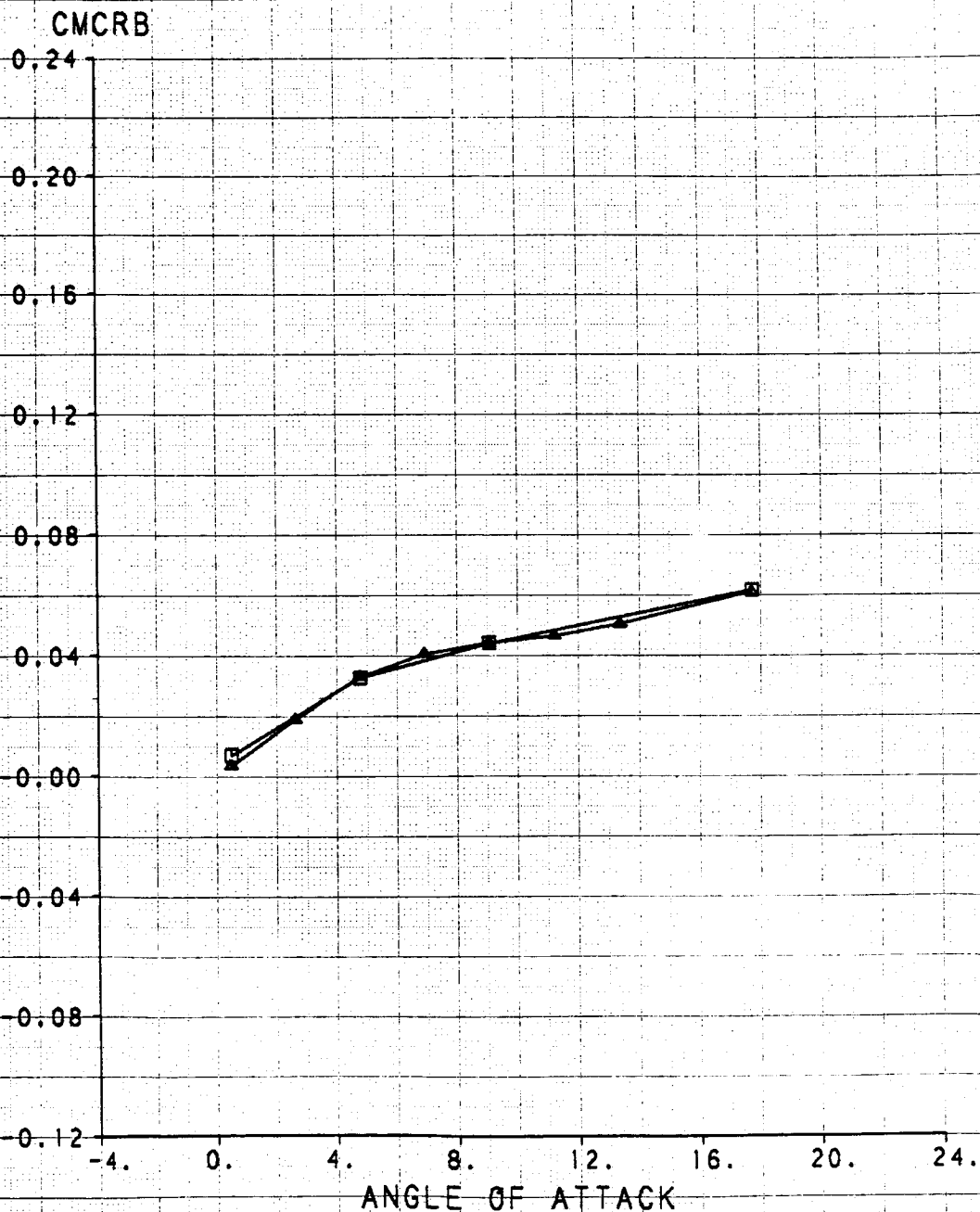
CMCRB vs ANGLE OF ATTACK

NOZZLE PRESSURE RATIO EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	RMFR	RNPRA	DESCRIPTION
□	514	211	0.8966	-4.9703	0.7627	2.4771	CMAPS,SIMULATED AIRCRAFT
▲	514	213	0.8953	-4.9849	0.7639	3.6541	CMAPS,SIMULATED AIRCRAFT
◇	514	214	0.8987	-4.9849	0.7595	4.3555	CMAPS,SIMULATED AIRCRAFT
⊙	514	215	0.8964	-4.9825	0.7534	5.3011	CMAPS,SIMULATED AIRCRAFT

CMCRB vs ANGLE OF ATTACK
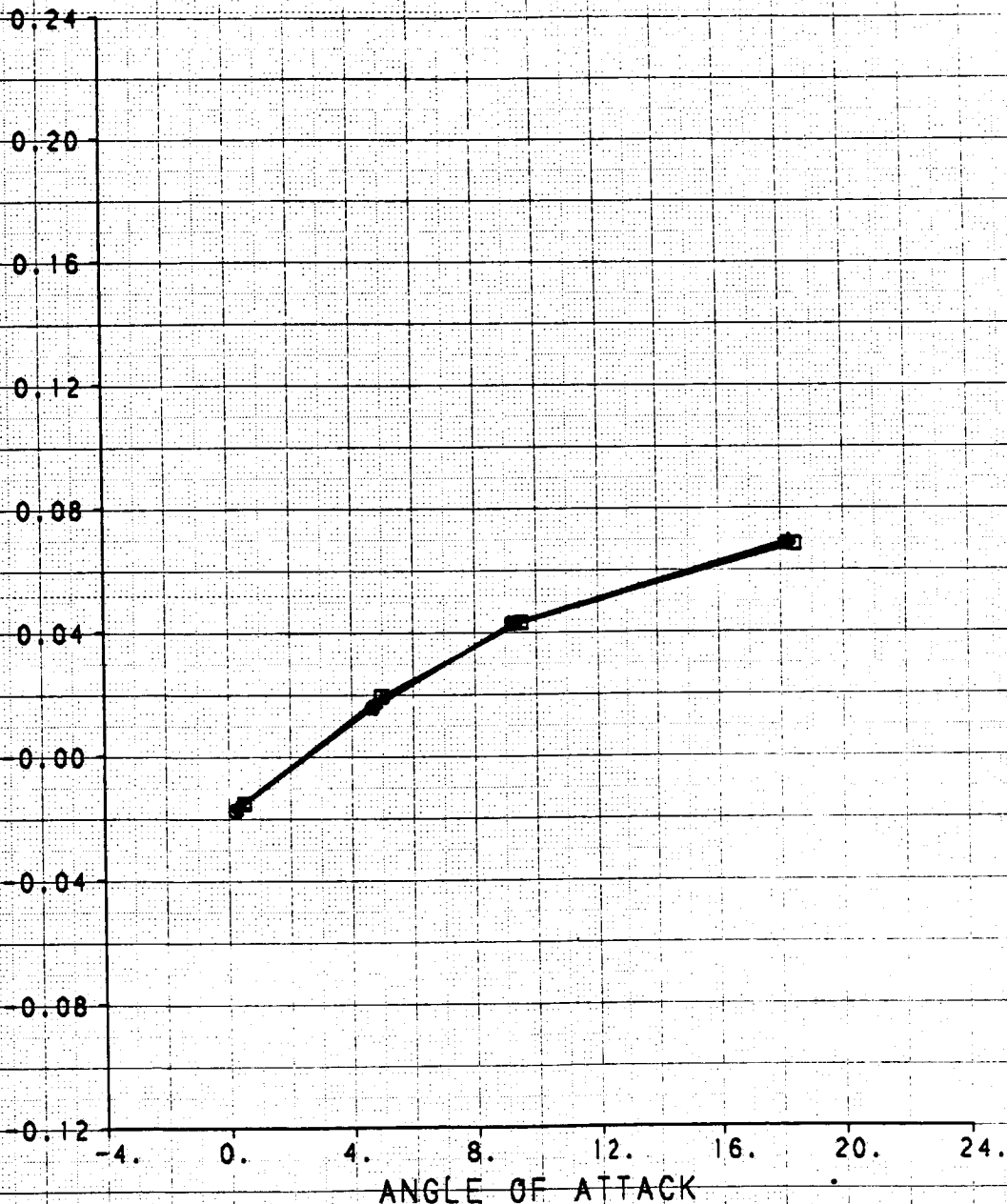
NOZZLE PRESSURE RATIO EFFECTS ON CANARD ROOT BENDING MOMENT

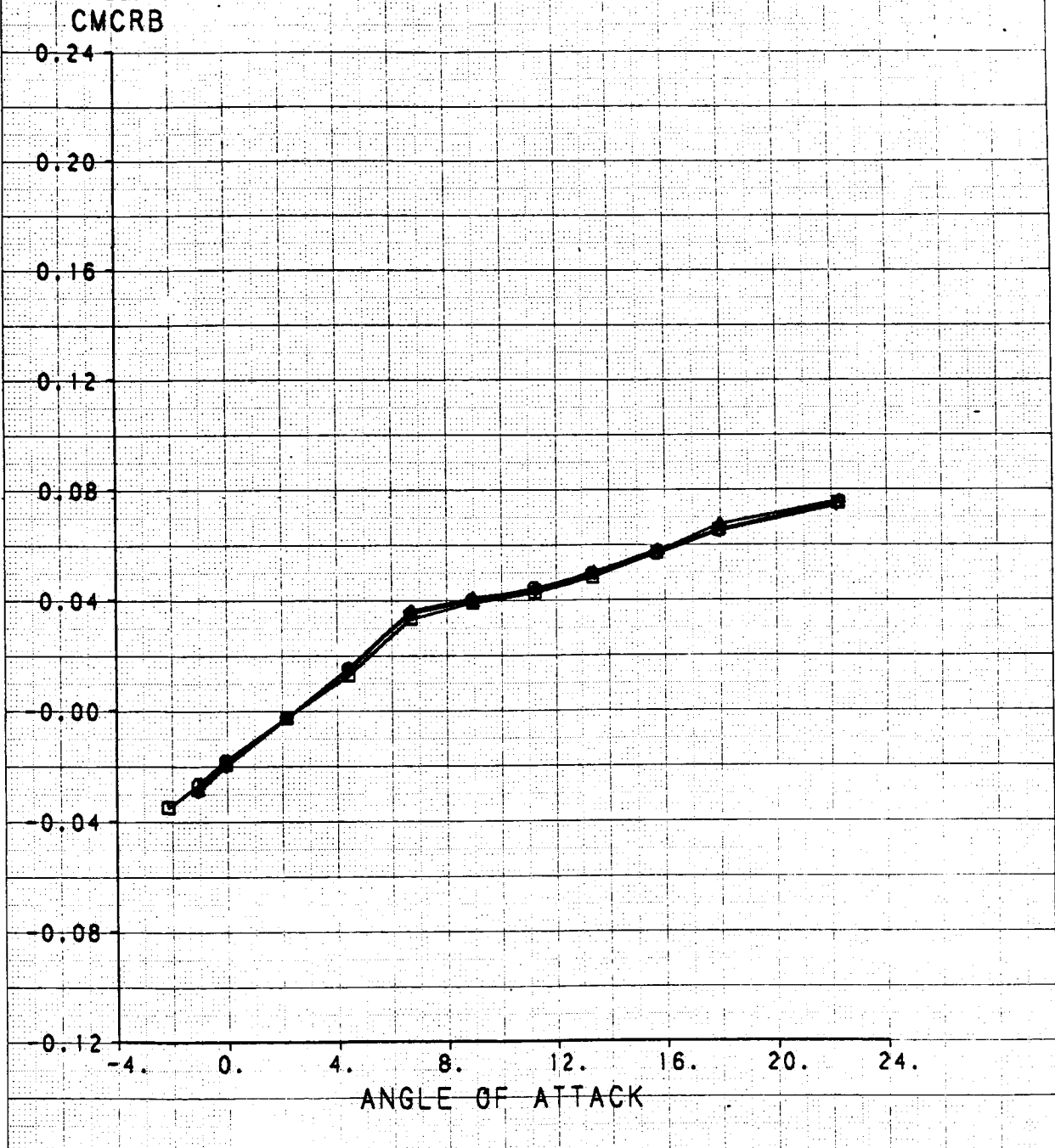| SYM	TEST	RUN	RMACH	RDELCL	RMFR	RNPRA	DESCRIPTION
□	514	239	1.1834	0.1042	0.6863	4.2464	CMAPS,SIMULATED AIRCRAFT
▲	514	240	1.1896	0.1083	0.6841	5.2134	CMAPS,SIMULATED AIRCRAFT
◇	514	241	1.1903	0.1125	0.6803	6.1521	CMAPS,SIMULATED AIRCRAFT
◉	514	242	1.1906	0.1042	0.7579	7.5840	CMAPS,SIMULATED AIRCRAFT
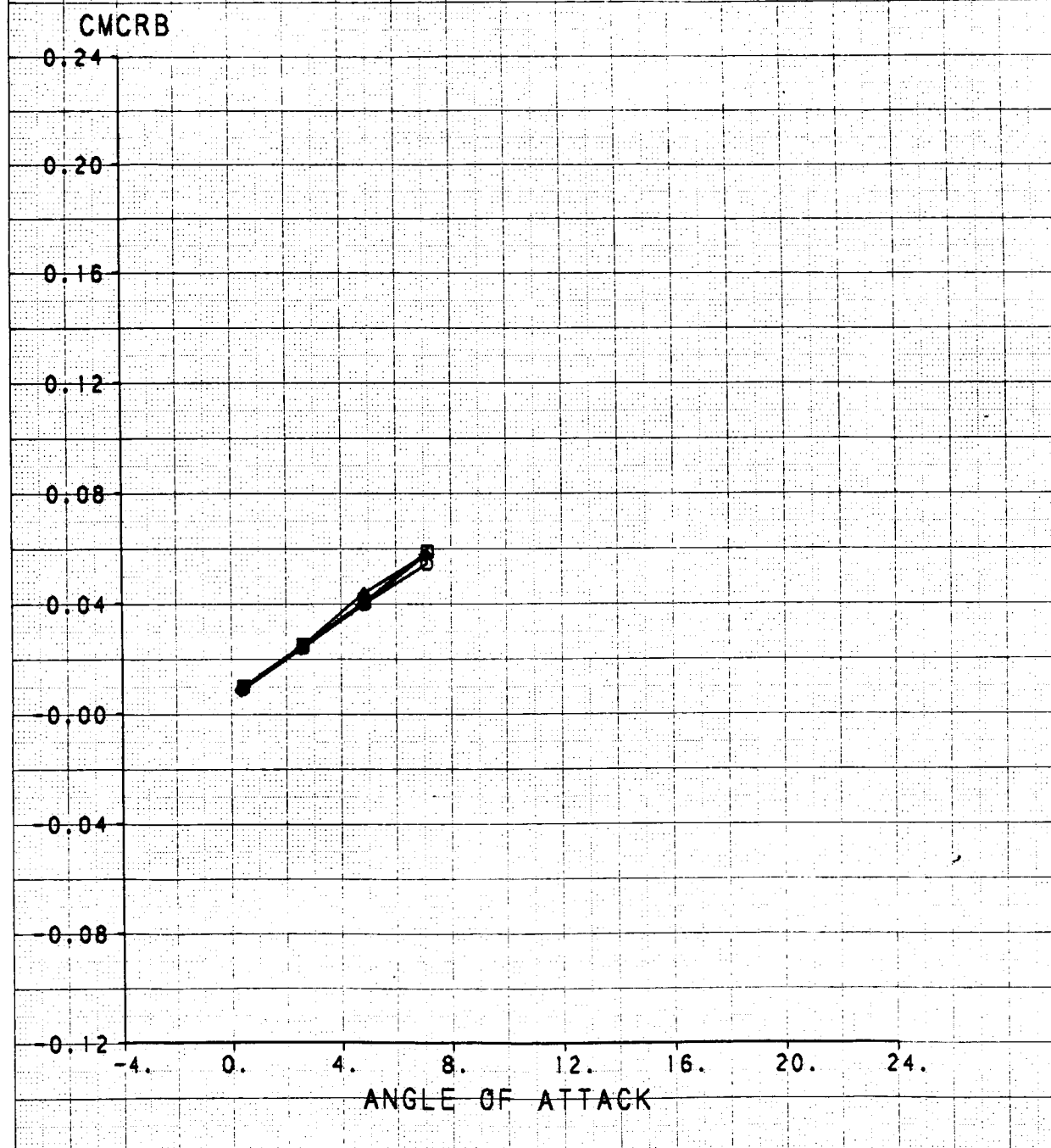
CMCRB

ANGLE OF ATTACK

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NOZZLE PRESSURE RATIO EFFECTS ON CANARD ROOT BENDING MOMENT

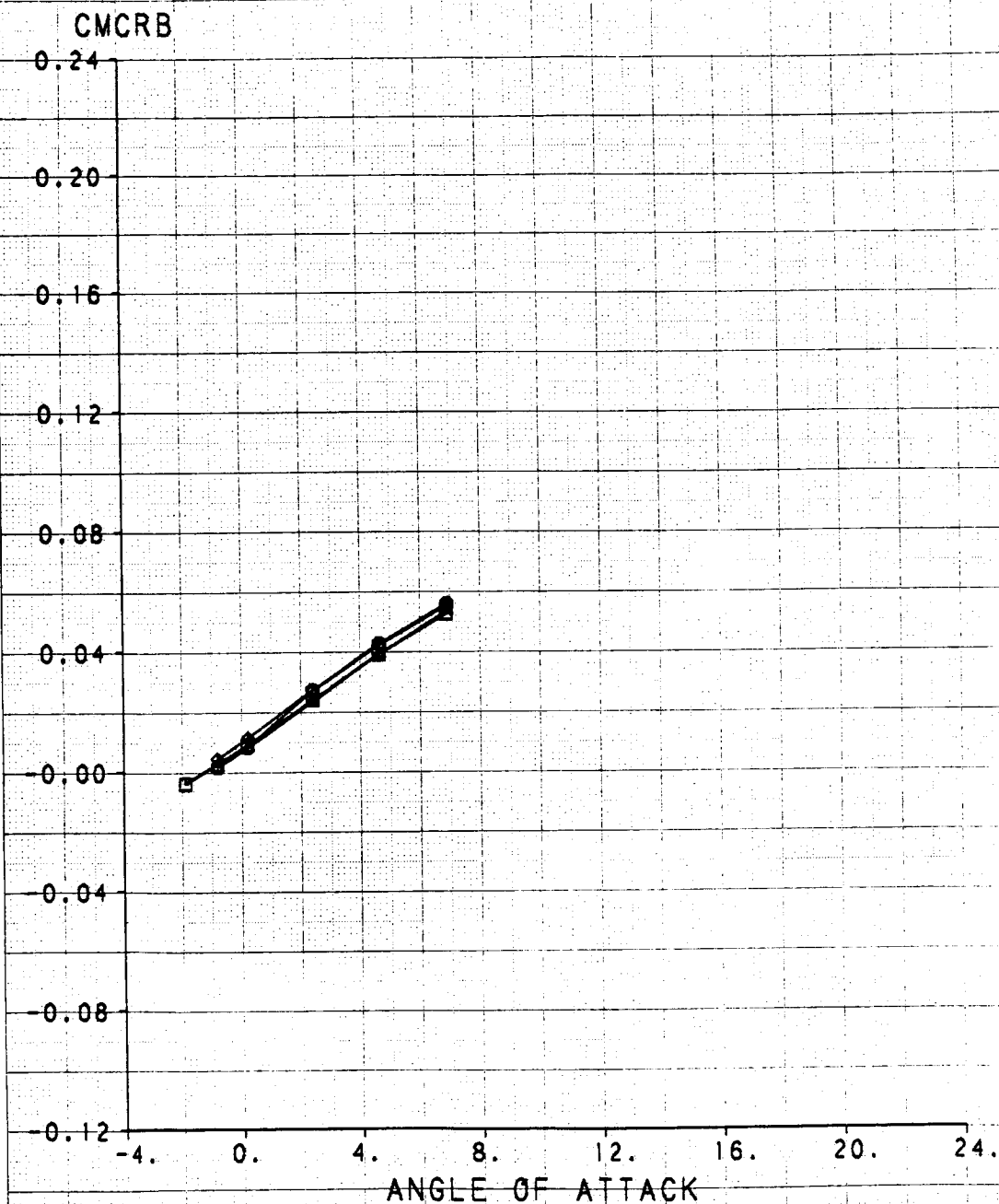| SYM	TEST	RUN	RMACH	RDELCL	RMFR	RNPRA	DESCRIPTION
▢	514	253	1.3958	0.1281	0.7198	5.4634	CMAPS,SIMULATED AIRCRAFT
▲	514	254	1.3978	0.1229	0.7203	6.6757	CMAPS,SIMULATED AIRCRAFT
◇	514	255	1.3966	0.1322	0.7118	7.8725	CMAPS,SIMULATED AIRCRAFT
◉	514	256	1.3969	0.1083	0.7929	9.5970	CMAPS,SIMULATED AIRCRAFT
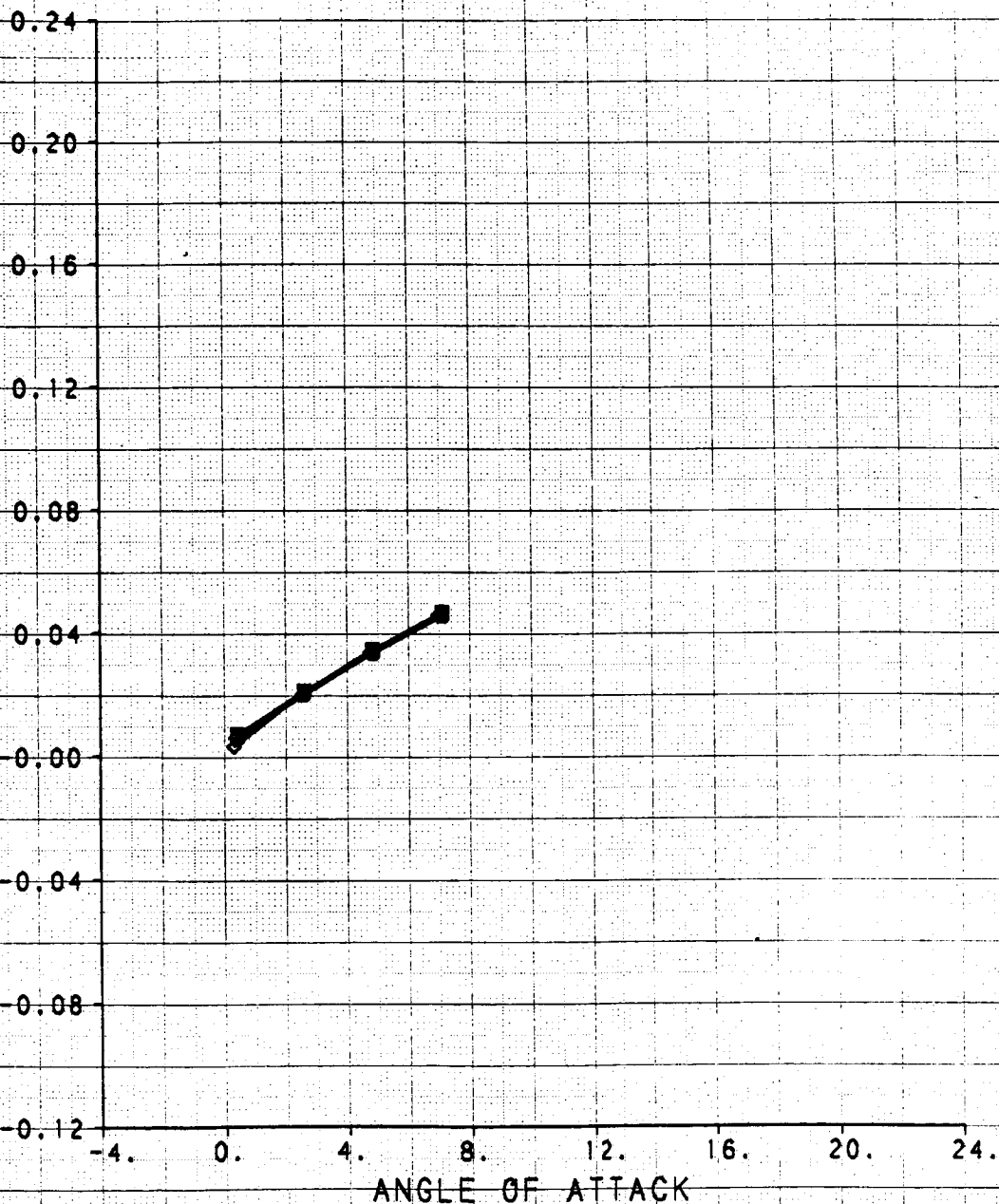
CMCRB vs ANGLE OF ATTACK

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THRUST VECTORING EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	RNPRA	DESCRIPTION
▢	514	257	0.3966	-4.9911	4.0323	J/E,COMMON BASELINE JET-ON
▲	514	271	0.3987	-4.9354	4.0129	J/E,20 DEG ALBEN A/B
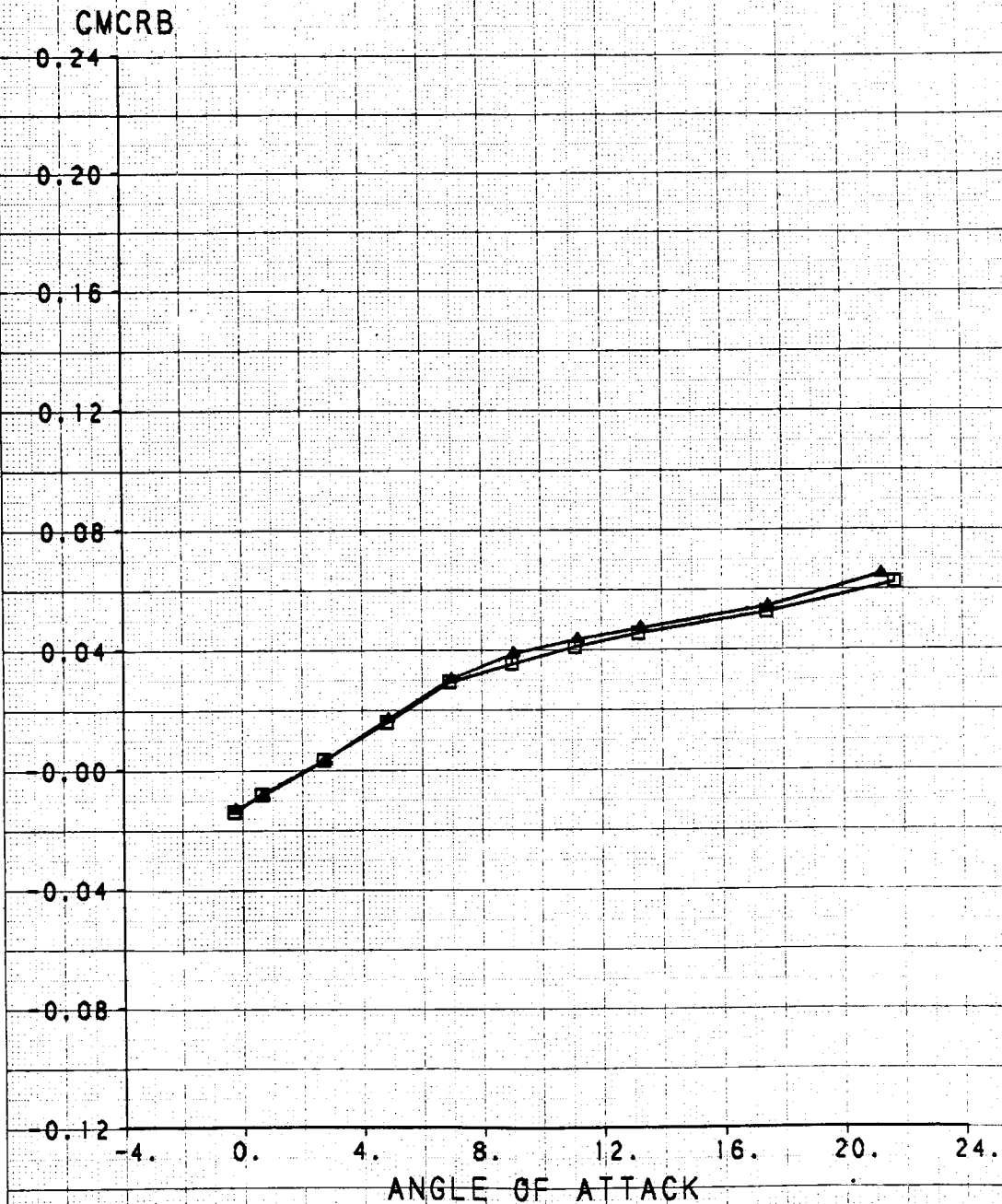
CMCRB

ANGLE OF ATTACK

THRUST VECTORING EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	RNPRA	DESCRIPTION
☐	514	256	0.8000	-4.9763	4.1998	J/E,COMMON BASELINE JET-ON
▲	514	276	0.5991	-4.9460	4.2228	J/E,20 DEG ALBEN A/B
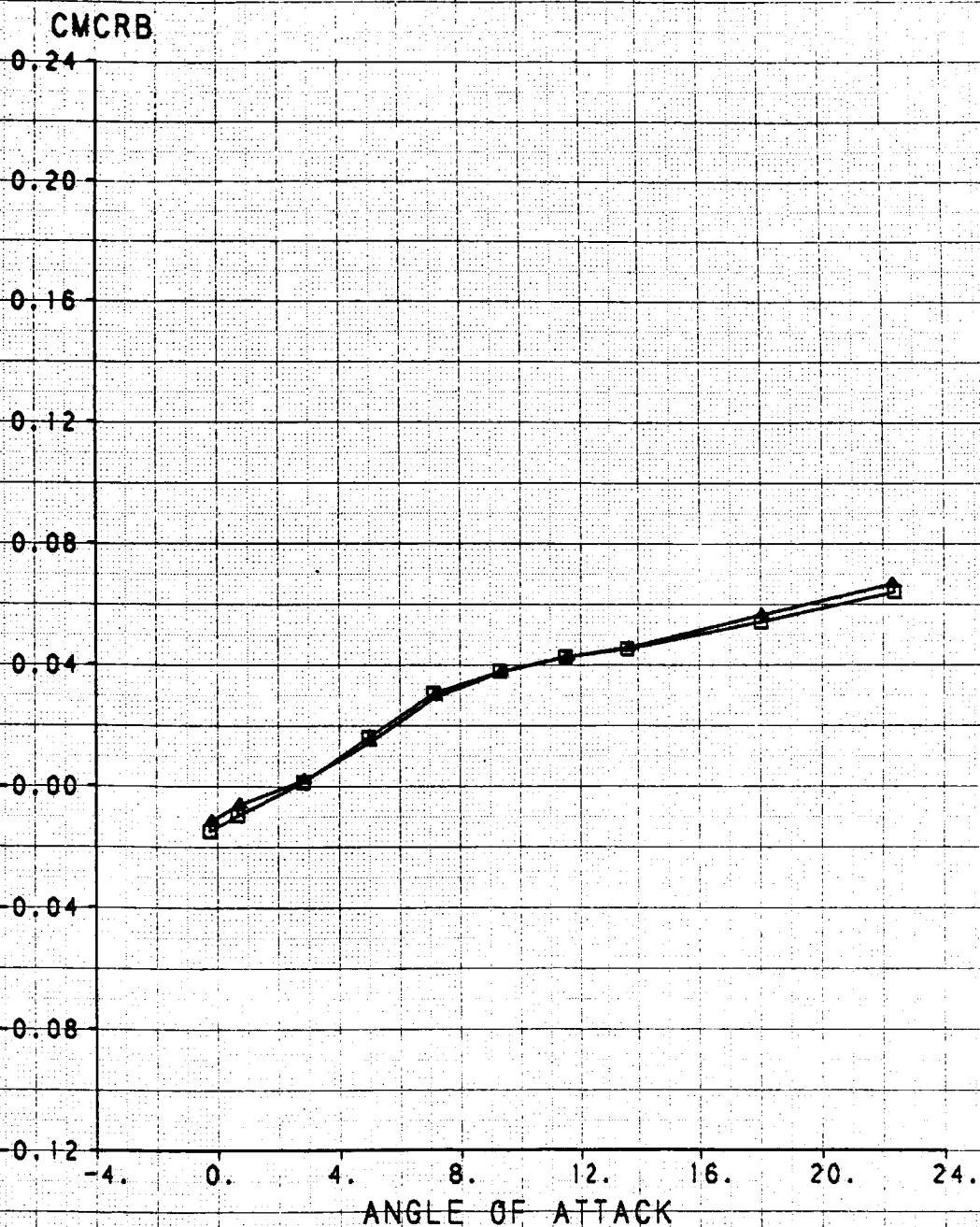
THRUST VECTORING EFFECTS ON CANARD ROOT BENDING MOMENT

SYM	TEST	RUN	RMACH	RDELCL	RNPRA	DESCRIPTION
□	514	250	0.8999	-4.9737	6.2195	J/E,COMMON BASELINE JET-ON
▲	514	280	0.9061	-4.9963	6.2122	J/E,20 DEG ALBEN A/B

CMCRB

ANGLE OF ATTACK

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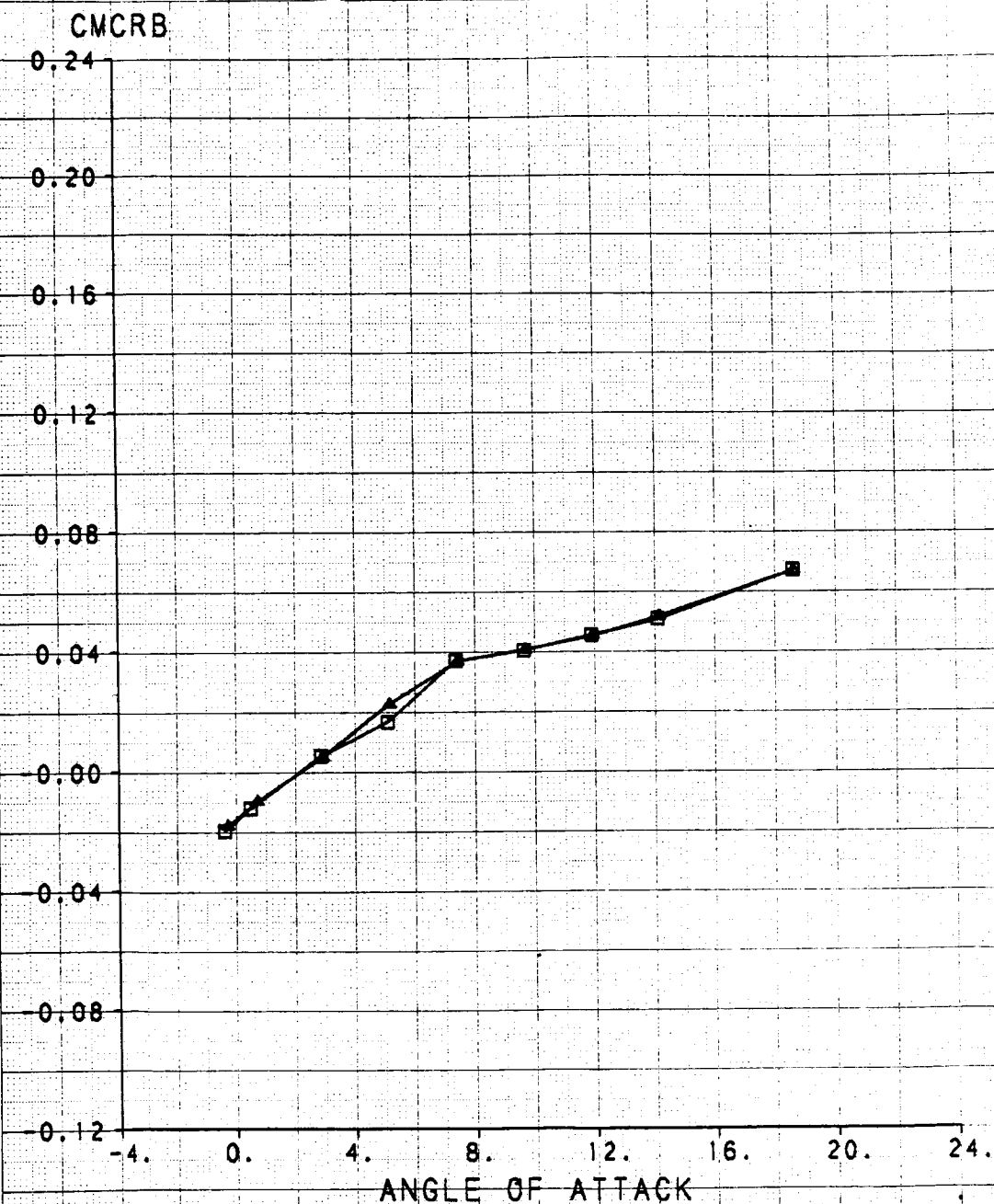
APPENDIX B
TEST MATRICES

The Phase 3 wind tunnel tests were performed over the range M = 0.4-1.4. Each run comprised either an Angle of Attack (α) sweep or a Nozzle Pressure Ratio (NPR) sweep. The run matrix for each test mode is presented in this appendix.

Flow-Through Test Mode

Configuration	δ_c	0.4 (Ejectors)	0.6 Ejectors With	0.6 W/O	0.9	1.2	1.4
Common Baseline A/B ALBEN $\delta_N = 0°$ $\delta_F = 0°$	5	66	75		77	82	93
	0	67	74		78	85	92
	-5	68	73		79	86	94
	-10	69	72		80	87	95
	-15	70	71		81	–	–
Nozzle Extension $A_{choke} = 12.49$ cm^2 (1.936 in^2)	5	186	–	–	–	–	–
	0	187	111	194	118	121	124
	-5	188	112	193	117	120	123
	-10	189	113	192	116	119	122
	-15	190	114	191	115	–	–
$A_{choke} = 18.74$ cm^2 (2.907 in^2)	5	204	–	–	–	–	–
	0	205	136	212	132	129	126
	-5	206	137	211	133	130	127
	-10	207	138	210	134	131	128
	-15	208	139	209	135	–	–
$A_{choke} = 26.11$ cm^2 (4.047 in^2)	5	176	–	–	–	–	–
	0	177	153	181	146	145	142
	-5	178	152	182	147	144	143
	-10	179	151	183	148	–	–
	-15	180	150	184	149	–	–
$A_{choke} = 34.25$ cm^2 (5.309 in^2)	5	164	–	–	–	–	–
	0	165	170	–	155	160	161
	-5	167	171	–	156	159	162
	-10	168	172	–	157	–	–
	-15	169	173	–	158	–	–

Flow-Through Test Mode

Configuration	δ_c	0.4	0.6	0.9	1.2	1.4
Nozzle Extension $\delta_F = 30°$ Cowl Lip = 45° $A_{choke} = 12.49$ cm^2 (1.936 in^2)	5	Ejectors 196				
	0	197				
$A_{choke} = 18.74$ cm^2 (2.907 in^2)	5	203				
	0	201 202				
$A_{choke} = 26.11$ cm^2 (4.047 in^2)	5	200				
	0	199				
Nozzle Extension $\delta_F = 0°$ Cowl Lip = 45° $A_{choke} = 34.25$ cm^2 (5.309 in^2)	-5		215	214		
Nozzle Extension Baseline	0	-	-	-	219	217/218
	-5	224	223	220 222 221	-	-
	-15	-	-	-	-	-

Jet-Effects Mode

Configuration	δ_c	0.4 α-Sweeps Jet Off	0.4 Jet On	0.4 α=0 NPR Sweeps	0.6 α-Sweeps Jet Off	0.6 Jet On	0.6 α=0 NPR Sweeps	0.9 α-Sweeps Jet Off	0.9 Jet On	0.9 α=0 NPR Sweeps	1.2 α-Sweeps Jet Off	1.2 Jet On	1.2 α=0 NPR Sweeps	1.4 α-Sweeps Jet Off	1.4 Jet On	1.4 α=0 NPR Sweeps
A/B ALBEN $\delta_N=0°$ $\delta_F=0°$	5 0 -5 -10 -15	239 240 237 238 241 242	257 258	248 256	243	259	260	244	250 262	249 261	245	252	251	246	254	253
A/B ALBEN $\delta_N=20°$ $\delta_F=0°$	0 -5 -10 -15	273	271	272	268	270	269	274 265 275 276 277	281 267 280 279 278	266						
A/B ALBEN $\delta_N=30°$ $\delta_F=30°$	5 0 -5	297 298 299	292 289 290 288 291 287 293 294	286							284	282	283			
Dry ALBEN $\delta_N=0°$ $\delta_F=0°$	0 -5	302 303	321 305 320	304 307	312	313 314	310	318 319	317 315	316						

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CMAPS MODE

Configuration	δ_c	Alpha-Sweeps 0.4	0.6	0.9	1.2	1.4
Common Baseline A/B ALBEN $\delta_N = 0°$ $\delta_F = 0°$	5 0 -5 -10 -15	104 105 106 107 108	109	110	111	112
Nozzle Extensions *Percent Design Corrected Flow Rate: 38%	5 0 -5 -10 -15	26 30 34 38 42	- 47 51 55 -	- 59 63 67 -	- 71 75 - -	- 79 83 - -
58%	5 0 -5 -10 -15	27 31 35 39 43	- 52 48 56 -	- 60 64 68 -	- 72 76 - -	- 80 84 - -
84%	5 0 -5 -10 -15	28 32 36 40 44	- 53 49 57 -	- 61 65 69 -	- 73 77 - -	- 81 85 - -
96% @ M = 0.4, 0.6 106% @ M = 0.9, 1.2, 1.4	5 0 -5 -10 -15	29 33 37 41 45	- 54 50 57 -	- 62 66 70 -	- 74 78 - -	- 82 86 - -

*Design Corrected Flow Rate:
 0.7049 kg/sec
 (1.554 lb/sec)

C-4

Simulator Mode
Mach = 0.6
ALBEN A/B $\delta_N = 0°$

EPR – Sweeps

*Percent Design Corrected Flowrate	δ_c	AOA			
		0°	4°	8°	16°
38%	0	114	131	146	–
	–5	120	136	151	–
	–10	125	141	156	–
58%	0	115	132	147	161
	–5	121	137	152	166
	–10	126	142	157	170
71%	0	116	133	148	162
	–5	122	138	153	167
	–10	127	143	158	171
84%	0	117	134	149	163
	–5	123	139	154	168
	–10	128	144	159	172
97%	0	118	135	150	164/165
	–5	124	140	155	169
	–10	129	145	160	173

*Design Corrected Flow Rate =

0.7049 kg/sec
(1.554 lb/sec)

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Simulator Mode
α-Sweeps

*Percent Design Flow Rate	δ_c	Mach 0.4							0.6						0.9							1.2							1.4						
	EPR →	1.2	1.5	1.8	2.2	2.6	3.0	3.2	1.2	1.5	1.8	2.2	2.6	3.0	1.2	1.5	1.8	2.2	2.6	3.0	3.2	0.47	1.2	1.5	1.8	2.2	2.6	3.2	0.47	1.2	1.5	1.8	2.2	2.6	3.2
38%	0																					233							250						
	−5																					243							257						
58%	0	265													184																				
	−5	280													202																				
	−10														217																				
71%	0	266	267	268											185	186	187																		
	−5			281											203	204	205																		
	−10														218	220	221																		
84%	0	269	270	271	272	273									188	189	190	191	192				236	238	239	240	241	242		251	252	253	254	255	256
	−5			282											206	207	208	209	210				244	245	246	247	248	249		258	259	260	261	262	
	−10														222	223	224	225	226																
96%	+5						289						174	178																					
	0		274	275	276	277	278						175	179		193	194	195	196		197														263
	−5		283	284	285	286	290	288						180		211	212	213	214	292	215														
	−10						291	293						182		227	228	229	230		231														
106%	0															198	199	200		183	201														
	−5																216																		

*Design Corrected Flow Rate:

0.7049 kg/sec
(1.554 lb/sec)

APPENDIX C
DATA REDUCTION PROCEDURE

The overall model commonality between the three test modes (Jet-Effects, Flow-Through, and CMAPS) allowed a single force and moment data reduction procedure to be applied to all configurations. The balance outputs were corrected for seal, cavity, base, stream thrust, and ram drag tares, as summarized in Figure C-1. Typical values of the data reduction terms presented in Figure C-1 are shown in Figure C-2 for the CMAPS mode. A listing of the data reduction equations is also provided in this appendix.

Note: Parameters shown on left nacelle represent sum of left and right nacelles.
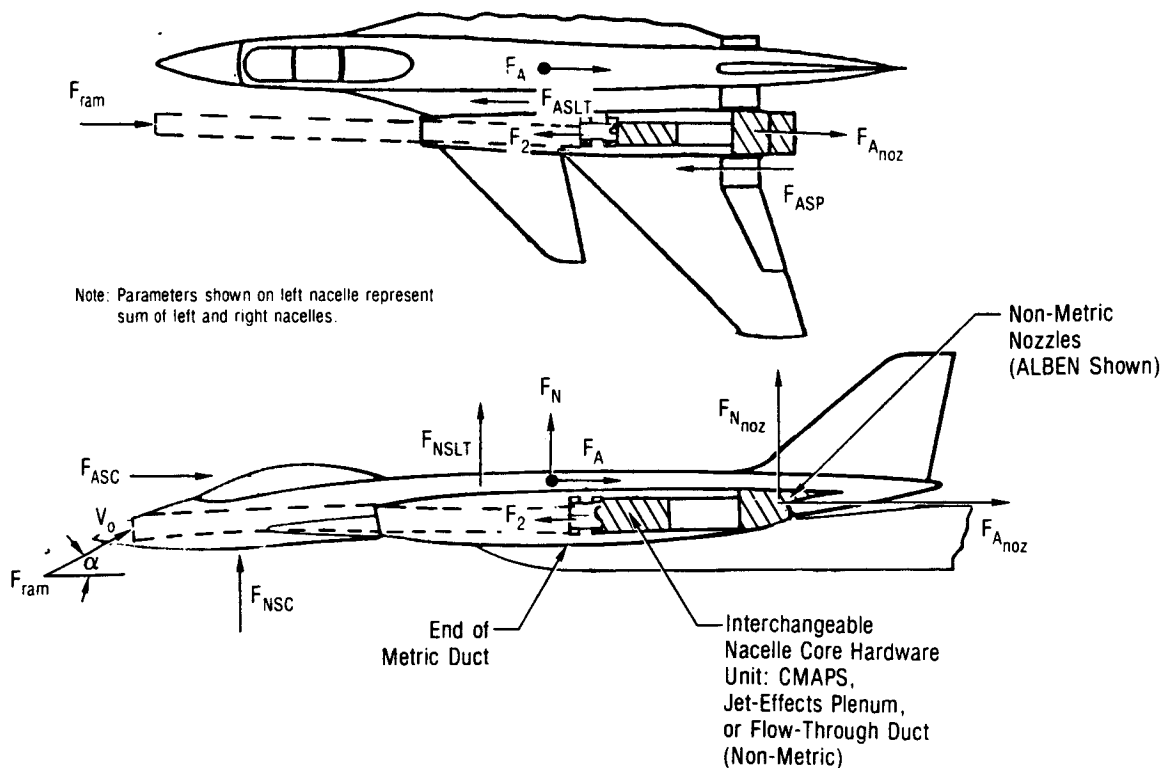
- Total Drag $= (F_A + F_{A_{noz}} + F_2 + F_{ASLT} - F_{ASC}$
  $+ F_{ASP}) \cos \alpha$
  $+ (F_N + F_{N_{noz}} - F_{NSC} - F_{NSLT}) \sin \alpha$
  $+ F_{ram}$

- Total Lift $= -(F_A + F_{A_{noz}} + F_2 + F_{ASLT} - F_{ASC} + F_{ASP}) \sin \alpha$
  $+ (F_N + F_{N_{noz}} - F_{NSC} - F_{NSLT}) \cos \alpha$

Note: With inlets faired: $F_2 = F_{ram} = 0$

Where: F_A = Total Airframe Balance Axial Force

F_N = Total Airframe Balance Normal Force

$F_{A_{noz}}$ = Pressure-Integrated Nozzle Axial Force

$F_{N_{noz}}$ = Pressure-Integrated Nozzle Normal Force

F_2 = Compressor Face Stream Thrust

F_{ram} = Inlet Ram Drag

F_{ASLT} = Inlet Duct Seal Axial Tare (Slope + Intercept Correction)

F_{NSLT} = Inlet Duct Seal Normal Tare (Slope + Intercept Correction)

F_{ASC} = Model Internal Cavity Axial Tare

F_{NSC} = Model Internal Cavity Normal Tare

F_{ASP} = Aft Metric Break Seal Axial Tare

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Figure C-1. Total Lift and Drag Data Reduction Summary

Term	Mach 0.9		Mach 1.4	
	$\alpha = 0.22°$ (lb)	$\alpha = 9.20°$ (lb)	$\alpha = 0.43°$ (lb)	$\alpha = 7.08°$ (lb)
$F_A =$	21.32	-60.82	67.76	46.48
$F_N =$	144.71	1,759.01	212.93	1,526.10
$F_{A_{noz}} =$	0.15	1.31	5.11	6.64
$F_{N_{noz}} =$	3.57	13.20	11.28	24.69
$F_2 =$	57.72	50.37	83.59	83.58
$R_{ram} =$	-47.30	-44.59	-62.58	-62.52
$R_{ASLT} =$	3.29	7.03	0.44	9.81
$R_{NSLT} =$	1.19	-5.17	-1.95	-7.66
$F_{ASC} =$	-4.42	-4.97	-10.45	-12.46
$F_{NSC} =$	18.31	20.59	43.30	51.63
$F_{ASP} =$	-0.02	-0.73	1.33	1.27

Axial force $= F_A + F_{A_{noz}} + F_2 + F_{ASLT} - F_{ASC} + F_{ASP}$

Normal Force $= F_N + F_{N_{noz}} - F_{NSC} - F_{NSLT}$

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Figure C-2. Typical Data Reduction Terms for Axial and Normal Force
Simulated Aircraft Configuration

DATA REDUCTION EQUATIONS

The following is a listing of the FORTRAN equations used for all of the data reduction. Comment cards are included to indicate which equations are unique to a particular test mode. Some of the flags and logic control statements have been omitted for clarity. Some of the calls to table look-ups and calls to subroutines have also been omitted. This list is intended to apply to all three test modes unless noted otherwise as comment cards.

```
C  *** CALCULATE THE FOLLOWING STANDARD PARAMETERS FROM TUNNEL MEASUREMENTS
C  *** OF PRESSURE AND TEMPERATURE:
C  ***                           PF=FREESTREAM STATIC PRESSURE (PSF)
C  ***                           PT=FREESTREAM TOTAL PRESSURE (PSF)
C  ***                           TT=FREESTREAM TOTAL TEMPERATURE (DEG F)
C  ***                           XMO=FREESTREAM MACH NUMBER
C  ***                           Q=FREESTREAM DYNAMIC PRESSURE (PSF)
C  ***                           VO=FREESTREAM VELOCITY (FPS)
C
       TTR=TT+459.7
       PTO=PT/144
       PO=PF/144
       XMO=SQRT(((PT/PF)**0.2857-1)*5)
       Q=0.7*PF*XMO**2
       QO=Q/144
       VO=XMO*(2403.076*(TTR/(1+0.2*XMO**2)))**0.5
C
C  *** PRESSURE MEASUREMENTS ***
C
C  *** THE PRESSURES (K=2 TO 47) MEASURED AT THE SCANIVALVES (J=1 TO 7)
C  *** IN PSF ARE CONVERTED TO PSI, CODED GOOD OR BAD, AND STORED IN
C  *** THE ARRAY P(J,K)
C
       DO 110 J=1,7
       DO 100 K=2,47
       P(J,K)=PRESSSV(J,K)*C(J,K)/144
100    CONTINUE
110    CONTINUE
C
C  *** C(J,K)=1 FOR GOOD.PRESSURE
C           0 FOR BAD PRESSURE
C
C  *** CALCULATE PRESSURE COEFFICIENTS ***
C
       DO 210 J=1,7
       DO 200 J=2,47
       CP(J,K)=(PRESSSV(J,K)-PF)/Q
200    CONTINUE
```

```
210     CONTINUE
C
C *** CALCULATE INLET AVERAGE TOTAL AND STATIC PRESSURES;
C ***         I=1 FOR LEFT HAND SIDE
C ***         I=2 FOR RIGHT HAND SIDE
C
        CSUM=0
        PSUM=0
        DO 300 K=28,38
        J=4
        PSUM=PSUM+P(J,K)
        CSUM=CSUM+C(J,K)
        PT2(1)=PSUM/CSUM
300     CONTINUE
C
        CSUM=0
        PSUM=0
        DO 400 K=12,13
        J=4
        PSUM=PSUM+P(J,K)
        CSUM=CSUM+C(J,K)
        PS2(1)=PSUM/CSUM
400     CONTINUE
C
        CSUM=0
        PSUM=0
        DO 500 K=19,45
        J=3
        PSUM=PSUM+P(J,K)
        CSUM=CSUM+C(J,K)
        PT2(2)=PSUM/CSUM
500     CONTINUE
C
        CSUM=0
        PSUM=0
        DO 600 K=12,16
        J=3
        PSUM=PSUM+P(J,K)
        CSUM=CSUM+C(J,K)
        PS2(2)=PSUM/CSUM
600     CONTINUE
C
C *** AVERAGE COMPRESSOR INLET STATIC PRESSURE
C
        PIDS=(PS2(1)+PS2(2))/2
C
C *** NOTE: IF PRESSURES ARE BAD CODED SUCH THAT EITHER PS2(1) OR PS2(2)
C ***       IS EQUAL TO ZERO, THEN ELIMINATE THE DIVISION BY TWO IN
C ***       PRECEDING EQUATION.
```

```
C
C *** CAVITY PRESELTE
C
        CSUM=0
        PSUM=0
        J=1
        DO 700 K=45,46
        PSUM=PSUM+P(J,K)
700     CSUM=CSUM+C(J,K)
        J=2
        DO 710 K=8,8
        PSUM=PSUM+P(J,K)
710     CSUM=CSUM+C(J,K)
        J=2
        DO 720 K=32,34
        PSUM=PSUM+P(J,K)
720     CSUM=CSUM+C(J,K)
        J=2
        DO 730 K=36,38
        PSUM=PSUM+P(J,K)
730     CSUM=CSUM+C(J,K)
        J=4
        DO 740 K=16,18
        PSUM=PSUM+P(J,K)
740     CSUM=CSUM+C(J,K)
C
        PCAV=PSUM/CSUM
C
C *** CAVITY PRESSURE COEFFICIENT
C
        CPCAVA=(PCAV-P0)/Q0
C
C *** INLET DUCT SEAL PRESSURE DIFFERENTIAL
C
        DPDS=PIDS-PCAV
C
C *** CALCULATE EXIT CHOKE AVERAGE TOTAL AND STATIC PRESSURES;
C ***        I=1 FOR LEFT HAND SIDE
C ***        I=2 FOR RIGHT HAND SIDE
C
        CSUM=0
        PSUM=0
        DO 800 K=20,21
        J=5
        PSUM=PSUM+P(J,K)
800     CSUM=CSUM+C(J,K)
        DO 810 K=28,34
        J=5
        PSUM=PSUM+P(J,K)
810     CSUM=CSUM+C(J,K)
```

```
C
        PTNC(1)=PSUM/CSUM
C
        CSUM=0
        PSUM=0
        DO 900 K=33,37
        J=5
        PSUM=PSUM+P(J,K)
900     CSUM=CSUM+C(J,K)
C
        PSNC(1)=PSUM/CSUM
C
        CSUM=0
        PSUM=0
        DO 1000 K=5,8
        J=6
        PSUM=PSUM+P(J,K)
1000    CSUM=CSUM+C(J,K)
        DO 1010 K=10,11
        J=6
        PSUM=PSUM+P(J,K)
1010    CSUM=CSUM+C(J,K)
        PSUM=PSUM+P(6,13)+P(6,16)+P(6,22)
        CSUM=CSUM+C(6,13)+C(6,16)+C(6,22)
C
        PTNC(2)=PSUM/CSUM
C
        PSUM=0
        CSUM=0
        PSUM=P(6,12)+P(6,17)+P(6,20)+P(6,21)
        CSUM=C(6,12)+C(6,17)+C(6,20)+C(6,21)
C
        PSNC(2)=PSUM/CSUM
C *** CALCULATE ALBEN AVERAGE TOTAL PRESSURES;
C                                 I=1 FOR LEFT HAND SIDE
C                                 I=2 FOR RIGHT HAND SIDE
C
        PSUM=0
        CSUM=0
        DO 1100 K=5,8
        J=7
        PSUM=PSUM+P(J,K)
1100    CSUM=CSUM+C(J,K)
C
        PTNA(1)=PSUM/CSUM
C
        PSUM=0           .
        CSUM=0
        DO 1110 K=5,8
        J=7
```

```
          PSUM=PSUM+P(J,K)
1110      CSUM=CSUM+C(J,K)
C
          PTNA(2)=PSUM/CSUM
C
C *** ALBEN STATIC PRESSURE FROM VEER MEASUREMENTS
C
          PSUM=0
          CSUM=0
          DO 1200 K=2,4
          J=7
          PSUM=PSUM+P(J,K)
1110      CSUM=CSUM+C(J,K)
C
          PVEERA=PSUM/CSUM
C
C
C *** TEMPERATURE MEASUREMENTS
C                        .
C
C *** DRIVE AND BLEED LINE TEMPS.(CMAPS MODE ONLY)
C
          TTRDV=TTDV+459.7
          TTRBV=TTBV+459.7
C
C *** AVERAGE NOZZLE TEMPERATURES (DEG F)
C
C           I=1,L/H SIDE    I=1,R/H SIDE
C
          T7(1)=(T711+T712)/2
          T7(2)=(T721+T722)/2
C
C *** CONVERSION TO RANKINE
C
          TT7(1)=T7(1)+459.7
          TT7(2)=T7(2)+459.7
C
C *** CORRECTION FACTOR TO STANDARD DAY TEMPERATURE
C
          THETA=SQRT(TTR/518.69)
C
C *** ANGLE MEASUREMENTS ***                  .
C
C *** NOTE:   THE MODEL NOZZLES ARE NON-METRIC (I.E. NOT ATTACHED TO THE
C ***         AIRCRAFT BALANCE, BUT GROUNDED TO THE STING).  IN ORDER TO
C ***         RESLOVE NOZZLE FORCES FROM PRESSURE INTEGRATION, THE NOZZLE
C ***         OR STING ANGLE MUST BE COMPUTED, IN ADDITION TO THE MODEL OR
C ***         BALANCE ANGLE:
C                           NOZZLE ALPHA = BALALPHA(1)
C                           MODEL ALPHA = BALALPHA(2)
```

```
C ***           BALALPHA(1 AND 2) ARE CALCULATED FROM THE NASA-AMES STANDARD
C ***           DATA REDUCTION EQUATIONS AND INCLUDE STING AND BALANCE
C ***           DEFLECTIONS DUE TO ELASTIC BENDING.  A CORRECTION TERM WAS
C ***           ADDED TO EACH OF THESE ANGLES TO ACCOUNT FOR STING THERMAL
C ***           BENDING.  THIS CORRECTION TERM IS DENOTED "THRM".
C
C *** MODEL ANGLE OF ATTACK
C
      ALPHAM=BALALPHA(2)+THRM
C
C *** NOZZLE ANGLE OF ATTACK
C
      ALPHAN=BALALPHA(1)+THRM
C
C *** NOTE: THRM IS DEFINED SEPARATELY FOR EACH TEST MODE
C
C *** FLOW-THROUGH MODE:
C
      THRM=0.0
C
C *** JET-EFFECTS MODE:
C
      THRM=0.490140754+4.17191423E-3*(TTDV(1))-7.65960224E-3*(TTBV(1))
C
C *** CMAPS MODE:
C
      THRM=-4.533611E-2+3.007169E-3*(TTDV(1))-4.558083E-3*(TTBV(1))
&           +3.152366E-2*(WDV(1))+0.37941*(WBV(1))+2.637508E-7*(NC(1))
C
C *** WHERE:  WDV(1)=LEFT HAND SIDE DRIVE LINE AIRFLOW (LB/SEC)
C            WBV(1)=LEFT HAND SIDE BLEED LINE AIRFLOW (LB/SEC)
C            NC(1)=LEFT HAND SIDE CORRECTED CMAPS ROTOR SPEED (RPM)
C
C *** THESE TERMS ARE CALCULATED LATER FOR THE CMAPS MODE
C
C
C
C *** BALANCE CORRECTIONS ***
C
C *** MODEL CAVITY CORRECTION
C
      NAFSC=CPCAVA*QO*ACAVN
C
      AFASC=CPCAVA*QO*ACAVA
C
      PMASC=NAFSC*XCAV+AFASC*ZCAV
C
C *** WHERE:  ACAVN=44.569 SQ.IN.
C            ACAVA=10.548 SQ.IN. FOR CMAPS AND FLOW-THROUGH MODES
C                 =24.892 SQ.IN. FOR JET-EFFECTS MODE
```

```
C                    XCAV =0.29167 FT.
C                    ZCAV =-0.15 FT.
C
C *** INLET DUCT SEAL CORRECTION
C
        FSEALN=0.0
        FSEALA=TABLE LOOK UP FUNCTION OF DPDS
        MSEALA=TABLE LOOK UP FUNCTION OF DPDS
C
C *** SEE FIGURES 3-18 AND 3-19 IN TEXT FOR DEFINITION OF TABLES
C
C *** INLET DUCT SEAL CORRECTION - A FUNCTION OF PRESSURE AND LOADS
C
        AFNSLT=KST28*NF+KST29*PM+KST30*AF
        AFASLT=KST31*NF+KST32*PM+KST33*AF
        APMSLT=KST34*NF+KST35*PM+KST36*AF
C
C *** WHERE: THE COEFFEICIENTS KST28 THROUGH KST36 ARE TABLE LOOK-UP
C ***        VALUES AS A FUNCTION OF THE BALANCE OUTPUTS (NF, PM, AF)
C ***        AND THE INLET DUCT SEAL PRESSURE DIFFERENTIAL (DPDS). (SEE
C ***        FIGURE 3-20 IN TEXT)
C
C *** NOTE:  ALL PITCHING MOMENT CORRECTIONS AND INPUTS IN FT-LBS.
C
C
C *** AFT SEAL CORRECTION
C
        DO 3000 I=1,5
        DO 3000 K=40,44
        J=1
3000    CP(I)=CP(J,K)
C
        DO 3010 I=6,8
        DO 3010 K=40,42
        J=2
3010    CP(I)=CP(J,K)
C
C
        CPSUM=0.0
        CPSUM1=0.0
        DO 3100 I=1,8
        CPSUM=CPSUM+CP(I)*ALA1(I)
3100    CPSUM1=CPSUM1+CP(I)*ALA1(I)*RPMA1(I)
C
        AFASP=Q0*CPSUM
        PMASP=Q0*CPSUM1
C
C
C *** WHERE: ALA1 AND RPMA1 ARE THE AFT FACING AREA AND THE MOMENT ARM
C ***        ASSOCIATED WITH THE PRESSURE TAPS AT THE AFT SEAL
```

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```
C
C ***            ALA1(1)=0.662 SQ.IN.        RPMA1(1)=-0.15 FT.
C                    (2)=1.466                  (2)=-0.030417
C                    (3)=0.732                  (3)=0.019167
C                    (4)=1.466                  (4)=-0.030417
C                    (5)=0.894                  (5)=-0.15
C                    (6)=0.368                  (6)=-0.269583
C                    (7)=0.368                  (7)=-0.319167
C                    (8)=0.368                  (8)=-0.269583
C
C
C *** TOTAL CAVITY CORRECTION ***
C
       ACAV(2)=AFASC+FSEALA+AFASP+AFASLT
       NCAV(2)=NAFSC+FSEALN+AFNSLT
       PMCAV(2)=PMASC+MSEALA+APMSLT+PMASP
C
C *** CONVERT TO COEFFICIENT FORM
C
       ACAVN=ACAV(2)/(Q*5.221 SQ.FT.)
       NCAVN=NCAV(2)/(Q*5.221 SQ.FT.)
       PMCAVN=PMCAV(2)/(Q*5.221 SQ.FT. * 1.368 FT.)
C
C
C *** NOTE: THE BALANCE CORRECTIONS DUE TO STREAM THRUST AND RAM DRAG ARE
C           CALCULATED LATER FOLLOWING THE CALCULATIONS OF AIRFLOW THROUGH
C           THE MODEL AND THE PRESSURE-AREA INTEGRATIONS OF NOZZLE FORCES
C           WHICH IMMEDIATELY FOLLOW HERE.
C
C *** NOZZLE PRESSURE-AREA INTEGRATED FORCES ***
C
C       ASSIGN THE VALUES OF NOZZLE PRESSURES FROM THE LARGE CP(J,K) ARRAY
C       TO A SMALLER ARRAY LABELED CPNOZ(I)
C
        DO 4000 I=1,19
        DO 4000 K=4,22
        J=5
4000    CPNOZ(I)=CP(J,K)
C
        DO 4010 I=20,31
        DO 4010 K=16,37
        J=5
4010    CPNOZ(I)=CP(J,K)
C
        DO 4020 I=32,51
        DO 4010 K=4,23
        J=6
4020    CPNOZ(I)=CP(J,K)
C
C       CALCULATE NORMAL FORCE AND AXIAL FORCE ON THE UPPER AND LOWER
```

```
C          HALVES OF THE ALBEN BY PERFORMING A PRESSURE AREA INTEGRATION
C
           NFNU=0.0
           DO 5000 I=1,31
           NFNU=NFNU+CPNOZ(I)*ALN(I)*QO
5000       CONTINUE
C
           NFNL=0.0
           DO 5010 I=32,51
           NFNL=NFNL+CPNOZ(I)*ALN(I)*QO
5010       CONTINUE
C
           AFNU=0.0
           DO 5020 I=1,31
           AFNU=AFNU+CPNOZ(I)*ALA(I)*QO
5020       CONTINUE
C
           AFNL=0.0
           DO 5030 I=32,51
           AFNL=AFNL+CPNOZ(I)*ALA(I)*QO
5030       CONTINUE
C
C          CALCULATE THE PITCHING MOMENT ON THE NOZZLE
C
           PMN=0.0
           DO 5040 I=1,51
           PMN=PMN+(CPNOZ(I)*ALN(I)*RPMN(I)*QO+CPNOZ(I)*ALA(I)*RPMA(I))
5040       CONTINUE
C
C
 *** NOZZLE FORCE COEFFICIENTS - BODY AXIS ***
C
           CNNU=2*NFNU/Q*5.221
           CNNL=2*NFNL/Q*5.221
           CANU=2*AFNU/Q*5.221
           CANL=2*AFNL/Q*5.221
C
           CNN=CNNU+CNNL
           CAN=CANU+CANL
C
           CPMN=2*PMN/12*5.221*1.368
C
C *** NOTE: MULTIPLICATION BY TWO IN EACH CASE IS TO GENERATE THE FORCE OR
C          MOMENT FOR TWO NOZZLES (THE PRESSURE INTEGRATION IS PERFORMED
C          ONLY ON ONE NOZZLE).  THE DIVISION BY TWELVE IN THE PITCHING
C          MOMENT COEFFICIENT EQUATION IS TO CONVERT THE NOZZLE PITCHING
C          MOMENT (PMN) TO THE UNITS OF FT-LB.
C
C *** NOZZLE FORCE COEFFICIENTS - STABILITY AXIS ***
C
```

```
        CLN=CNN*COS(ALPHAN)-CAN*SIN(ALPHAN)
        CDN=CNN*SIN(ALPHAN)+CAN*COS(ALPHAN)
C
C       CALCULATE APPROXIMATION FOR NOZZLE SKIN FRICTION
C
        NUM=0.455*(1+.2*XMO**2)**-0.467
        DEN(I)=(LOG((RN*10**6)*X(I)))**2.58
        CFN(I)=NUM/DEN(I)
C
C ***   NOTE: I=1 FOR LOWER SURFACE OF ALBEN
C             I=2 FOR UPPER SURFACE OF ALBEN
C
        NSF=Q*(CFN(2)*AWET(2)-CFN(1)*AWET(1))
C
C ***       X(1)=2.614 FT (CHARACTERISTIC LENGTH FOR LOWER SURFACE OF 2
C                          NOZZLES)
C           X(2)=3.297 FT (CHARACTERISTIC LENGTH FOR UPPER SURFACES)
C           AWET(1)=4.145 SQ.FT. (LOWER SURFACE WETTED AREA, 2 NOZZLES)
C           AWET(2)=5.202 SQ.FT. (UPPER SURFACE WETTED AREA, 2 NOZZLES)
C
        CDNSF=NSF/Q*5.221
C
C *** TOTAL NOZZLE DRAG INCLUDING SKIN FRICTION
C
        CDARONF=CDN+CDNSF
C
C
C
C
C
C *** AIRFLOW CALCULATIONS ***
C
C
C     CALCULATE THE AIRFLOW THROUGH DRIVE AND BLEED LINES FOR CMAPS AND
C     JET-EFFECTS MODES.  NO FLOW WAS DELIVERED TO THE MODEL FOR THE FLOW-
C     THROUGH TEST MODE.
C
C *** DRIVE LINE - CMAPS AND JET-EFFECTS MODES ***
C
C     NOTE: I=1 FOR LEFT HAND SIDE
C           I=2 FOR RIGHT HAND SIDE
C
C           PDV(I)=STATIC PRESSURE MEASURED IN DRIVE VENTURI
C           TTRDV(I)=TOTAL TEMPERATURE MEASURED IN DRIVE VENTURI
C
C       GAMMA=TABLE LOOK UP AS FUNCTION OF PDV(I) AND TTRDV(I)
C
C       PERFORM FOLLOWING ITERATION TO FIND MACH NUMBER IN VENTURI
C
100     J=0
```

```
          M(1)=0.01
          SUF=2/(GAMMA+1)
          TOP=(GAMMA+1)/2*(GAMMA-1)
          TOP1=(3-GAMMA)/2*(GAMMA-1)
200       J=J+1
          CORE=1+((GAMMA-1)/2)*M(J)**2
          NUMER=(((SUF*CORE)**TOP)/M(J))-AOAS(I)
C
C    NOTE: AOAS(I)=AOASD(1)=AOASD(2)=7 FOR DRIVE VENTURI
C                 =AOASB(1)=AOASB(2)=3 FOR BLEED VENTURI
C    AOAS=AREA RATIO OF VENTURI
C
          DENOM=((SUF*CORE)**TOP1)-((SUF*CORE)**TOP/M(J)**2)
          M(J+1)=M(J)-NUMER/DENOM
          TEST=ABS((M(J+1)-M(J))/M(J+1))
          IF TEST.LT.0.001 GOTO 300
          GO TO 200
300       MACH=M(J+1)
C
          PTDV(I)=PDV(I)*(1+((GAMMA-1)/2)*MACH**2)**(GAMMA/(GAMMA-1))
C
          GAMMA2=TABLE LOOK UP AS A FUNCTION OF PTDV(I) AND TTRDV(I)
          TEST2=ABS(GAMMA2-GAMMA)
          IF TEST2.LT.0.0005 GOTO 400
          GAMMA=GAMMA2
          GOTO 100
400       MACHV(I)=MACH
C *** END OF ITERATION
C
C *** NOTE: THIS ITERATION IS BASED ON THE ISENTROPIC FLOW EQUATION FOR
C           "A" OVER "A-STAR" AS A FUNCTION OF LOCAL MACH NUMBER AND
C           GAMMA.  THE TABLE LOOK-UPS FOR GAMMA ARE BASED ON A STANDARD
C           GAS TABLE.
C
C
C
C *** DRIVE VENTURI AIRFLOW
C
          TRDV(I)=TTRDV(I)/(1+0.2*MACHV(I)**2)
C
C    CORRECTED VENTURI AREA
C
          ADV(I)=(0.11 SQ.IN.)*(1+9.6E-6*(TRDV(I)-518.7))**2
C
C    CORRECTED VENTURI DIAMETER
C
          DDV(I)=SQRT(4*ADV(I)/PI)
C
C    INDICATED AIRFLOW
C
          CSTD(I)=TABLE LOOK-UP AS FUNCTION OF PDV(I) AND TTRDV(I)
```

```
C
        WDI(I)=(CSTD(I)*32.174*PTDV(I)*ADV(I))/SQRT(1716.5*TTRDV(I))
C
C  STATIC TEMPERATURE
C
        TSTD(I)=0.833333*TTRDV(I)
C
C  VISCOSITY
C
        VISCD(I)=(2.27E-8*TSTD(I)**1.5)/(TSTD(I)+198.6)
C
C  REYNOLDS NUMBER
C
        RNDVOT(I)=(4.74883E-6*WDI(I))/(DDV(I)*VISCD(I)*TTRDV(I)**4)
C
C  ACTUAL AIRFLOW
C
        CDDV(I)=TABLE LOOK-UP BASED ON VENTURI CALIBRATION
C
        WDV(I)=CDDV(I)*WDI(I)
C
C
C *** BLEED LINE -CMAPS MODE ONLY ***
C
C
C         PBV(I)=STATIC PRESSURE MEASURED IN BLEED VENTURI
C         TTRBV(I)=TOTAL TEMPERATURE MEASURED IN BLEED VENTURI
C
        GAMMA=TABLE LOOK UP AS FUNCTION OF PBV(I) AND TTRBV(I)
C
C     PERFORM FOLLOWING ITERATION TO FIND MACH NUMBER IN VENTURI.
C     THIS IS THE SAME ITERATION USED FOR THE DRIVE LINE.
C
100     J=0
        M(1)=0.01
        SUF=2/(GAMMA+1)
        TOP=(GAMMA+1)/2*(GAMMA-1)
        TOP1=(3-GAMMA)/2*(GAMMA-1)
200     J=J+1
        CORE=1+((GAMMA-1)/2)*M(J)**2
        NUMER=(((SUF*CORE)**TOP)/M(J))-AOAS(I)
C
C  NOTE: AOAS(I)=AOASD(1)=AOASD(2)=7 FOR DRIVE VENTURI
C              =AOASB(1)=AOASB(2)=3 FOR BLEED VENTURI
C  AOAS=AREA RATIO OF VENTURI
C
        DENOM=((SUF*CORE)**TOP1)-((SUF*CORE)**TOP/M(J)**2)
        M(J+1)=M(J)-NUMER/DENOM
        TEST=ABS((M(J+1)-M(J))/M(J+1))
        IF TEST.LT.0.001 GOTO 300
```

```
        GO TO 200
300     MACH=M(J+1)
C
        PTBV(I)=PBV(I)*(1+((GAMMA-1)/2)*MACH**2)**(GAMMA/(GAMMA-1))
C
        GAMMA2=TABLE LOOK UP AS A FUNCTION OF PTBV(I) AND TTRBV(I)
        TEST2=ABS(GAMMA2-GAMMA)
        IF TEST2.LT.0.0005 GOTO 400
        GAMMA=GAMMA2
        GOTO 100
400     MACHB(I)=MACH
C *** END OF ITERATION
C
C *** NOTE: THIS ITERATION IS BASED ON THE ISENTROPIC FLOW EQUATION FOR
C           "A" OVER "A-STAR" AS A FUNCTION OF LOCAL MACH NUMBER AND
C           GAMMA.  THE TABLE LOOK-UPS FOR GAMMA ARE BASED ON A STANDARD
C           GAS TABLE.
C
C
C *** BLEED VENTURI AIRFLOW - CMAPS MODE ONLY***
C
        TRBV(I)=TTRBV(I)/(1+0.2*MACHB(I)**2)
C
C   CORRECTED VENTURI AREA
C
        ABV(I)=(0.11 SQ.IN.)*(1+9.6E-6*(TRBV(I)-518.7))**2
C
C   CORRECTED VENTURI DIAMETER
C
        DBV(I)=SQRT(4*ABV(I)/PI)
C
C   INDICATED AIRFLOW
C
        CSTB(I)=TABLE LOOK-UP AS FUNCTION OF PBV(I) AND TTRBV(I)
C
        WBI(I)=(CSTB(I)*32.174*PTBV(I)*ABV(I))/SQRT(1716.5*TTRBV(I))
C
C  STATIC TEMPERATURE
C
        TSTB(I)=0.833333*TTRBV(I)
C
C  VISCOSITY
C
        VISCB(I)=(2.27E-8*TSTB(I)**1.5)/(TSTB(I)+198.6)
C
C  REYNOLDS NUMBER
C
        RNBV(I)=(4.74883E+10*WBI(I))/(DBV(I)*VISCB(I))
C
C  ACTUAL BLEED LINE AIRFLOW - INCLUDING SUBCRITICAL CONDITIONS
```

```
C
        PTBVQ(I)=PTBV(I)/P0
C
        BVP(I)=BLEED VALVE POSITION AS INPUT FROM CMAPS CONTROLLER
C
        IF BVP(I).GE.13.5 .AND. PTBVQ(I).GE.1.17 GO TO 100
        GOTO 200
        CDBV(I)=TABLE LOOK-UP BASED ON VENTURI CALIBRATION
C
100     WBV(I)=CDBV(I)*WBI(I)
        GO TO 500
200     IF BVP(I).GE.13.5 .AND. PTBVQ(I).LT.1.17 GO TO 300
        GO TO 400
300     PTEXP=PTBVQ(I)**(2/7)
        WBV(I)=((2.05464*ABV(I)*P0)/SQRT(TTRBV(I)))*PTEXP*SQRT(1-(1/PTEXP))
        GO TO 500
400     IF BVP(I).LT.13.5 .OR. PTBVQ(I).LT.1.0 WBV(I)=0.0
500     CONTINUE
C
C
C
C *** BLEED LINE AIRFLOW FOR JET-EFFECTS MODE ONLY ***
C
C
        IF PTBM(I).LT.100 GO TO 100
        GO TO 200
100     KMIX(I)=0.0035*PTBM(I)+0.75
        GO TO 500
200     IF PTBM(I).GE.100 .AND. .LE.400 GO TO 300
        GO TO 400
300     KMIX(I)=-2.357E-6*PTBM(I)**2+0.00165*PTBM(I)+0.9512
        GO TO 500
400     IF PTBM(I).GT.400 KMIX(I)=1.26
500     CONTINUE
C
        WMIX(I)=(KMIX(I)*0.1395*PTBM(I))/SQRT(TTRBV(I))
C
C       NOTE: THE AREA TERM (0.1395 SQ.IN.) WHICH IS USED ABOVE, IS THE AREA
C             IN THE MIXER CORRECTED FOR THE MIXER FLOW COEFFICIENT AND THE
C             FLOW RATE CONSTANT FOR CHOKED FLOW:
C                        0.1395=CDMIXER*AMIXER*0.5315
C
        WBV(I)=WMIX(I)
C
C
C
C
C
C *** THE CALCULATIONS FOR COMPRESSOR INLET AIRFLOW BEGIN ON THE NEXT PAGE
C
```

```
C *** COMPRESSOR INLET AIRFLOW CALCULATIONS ***
C
C    FLOW THROUGH MODE - IN THIS MODE, INLET AIRFLOW CALCULATIONS WERE
C    BASED ON MEASUREMENTS AT THE SIMULATED COMPRESSOR FACE AND AT THE
C    CHOKE NOZZLES ON THE EXTENSION DUCTS.  THESE ARE REFERRED TO AS THE
C    PLANE 2 AND PLANE 8 METHODS RESPECTIVELY.
C
C  PLANE 2 METHOD
C
       PRAT=PS2(1)/PT2(I)
       PREX=PRAT**(6/7)
       PREX2=(1/PRAT)**(2/7)
       W2(I)=((0.91886*7.07*PT2(I))/SQRT(TTR))*PREX*SQRT(5*(PREX2-1))
C
C  AVERAGE INLET AIRFLOW
C
       WAF2=(W2(1)+W2(1))/2
C
C  CORRECTED INLET AIRFLOW
C
C    SEA-LEVEL STANDARD DAY PRESSURE CORRECTION
C
       DEL(I)=PT2(I)/14.697
C
       W2R(I)=(W2(I)*THETA)/DEL(I)
C
C  PLANE 8 METHOD - USED WITH EXIT CHOKES
C
       PRCH(I)=PTNC(I)/PSNC(I)
       WTAP(I)=A+B*PRCH(I)+C*PRCH(I)**2+D*PRCH(I)**3
       IF PRCH(I).GT.PRMAXC WTAP(I)=WLIMC
       IF PRCH(I).LT.PRMINC WTAP(I)=0
C
C  NOTE:  THE FOLLOWING CONSTANTS ARE OBTAINED IN A TABLE LOOK-UP.
C         THESE TABLES WERE GENERATED IN STATIC CALIBRATIONS OF THE
C         CHOKES.  SEE REFERENCE 7 FOR A LISTING OF THESE TABLES.
C             A, B, C, D, WLIMC, PRMAXC, PRMINC, ATC=CHOKE AREA
C
       W8(I)=(WTAP(I)*PTNC(I)*ATC)/SQRT(TTR)
C
C    CORRECTED INLET AIRFLOW
C
       W8R(I)=(W8(I)*THETA)/DEL(I)
C
C
C
C ***CMAPS AIRFLOW CALCULATIONS BEGIN NEXT PAGE ***
C
C
```

300

```
C     CMAPS MODE - IN THIS MODE, INLET AIRFLOW CALCULATIONS WERE
C     BASED ON MEASUREMENTS AT THE SIMULATED COMPRESSOR FACE, THE
C     CHOKE NOZZLES ON THE EXTENSION DUCTS, THE COMPRESSOR DISCHARGE PLANE,
C     AND THE TURBINE DISCHARGE PLANE.  THESE ARE REFERRED TO AS THE
C     PLANE 2, PLANE 8, PLANE 15, AND PLANE 57 METHODS RESPECTIVELY.
C
C     PLANE 2 METHOD - THIS METHOD IS IDENTICAL TO THE FLOW-THROUGH MODE
C
        PRAT=PS2(1)/PT2(I)
        PREX=PRAT**(6/7)
        PREX2=(1/PRAT)**(2/7)
        W2(I)=((0.91886*7.07*PT2(I))/SQRT(TTR))*PREX*SQRT(5*(PREX2-1))
C
C     AVERAGE INLET AIRFLOW
C
        WAF2=(W2(1)+W2(2))/2
C
C     CORRECTED INLET AIRFLOW
C
        W2R(I)=(W2(I)*THETA)/DEL(I)
C
C     PLANE 8 METHOD - INSTRUMENTATION FAILURES PROHIBITED THE USE OF THIS
C                      METHOD THROUGHOUT THE CMAPS MODE.  THEREFORE, THE
C                      EQUATIONS ARE NOT LISTED HERE.  THE METHOD IS FULLY
C                      DESCRIBED IN THE TEXT.
C
C     PLANE 15 METHOD - BASED ON PRESSURE AND TEMPERATURE MEASUREMENTS MADE
C                       AT THE CMAPS COMPRESSOR DISCHARGE STATION.
C
        PRAT15(I)=PS15(I)/PT15(I)
        PREX15(I)=PRAT15(I)**(6/7)
        PREX25(I)=SQRT(5*((1/PRAT15(I))**(2/7)-1))
        DENOM(I)=SQRT(TT15(I)+459.7)
        W15I(I)=((0.91886*(3.4 SQ.IN.)*PT15(I))/DENOM(I))
     &  *PREX15(I)*PREX25(I)
C
        W15(I)=W15I(I)*CD15(I)
C
        CD15(I)=TABLE LOOK-UP AS A FUNCTION OF NCP(I) AND BVPOS(I)
C
C       NOTE:   NCP(I)=PERCENT CORRECTED ROTOR SPEED
C               BVPOS(I)=BLEED VALVE POSITION
C
C     PLANE 57 METHOD - THIS METHOD IS BASED ON A CORRELATION OF THE TURBINE
C                       DISCHARGE PRESSURE AND PERCENT CORRECTED ROTOR SPEED
C                       AS MEASURED DURING THE STATIC AIRFLOW CALIBRATIONS
C                       IN THE NASA-AMES 9X7 FT WIND TUNNEL.
C
C *** NOTE: PLANE 57 METHOD CONTINUED ON NEXT PAGE
C
```

```
C     LEFT HAND CMAPS
C
      PSQDELL=PS57L/DEL(1)
C
C     NOTE: PS57L (TURBINE DISCHARGE STATIC PRESSURE) IS INPUT FROM THE CMAPS
C           CONTROLER.
C
      NRPL=(NCPL/78185)*100
C
      DATA (XCOEFL(I),I=1,3)/.3875,-47.575,1601.25/
      DATA (YCOEFL(I),I=1,6)/3.9714795E-9,-1.7028217E-6,2.8122667E-4,
     1      -2.2420302E-2,8.8135679E-1,-12.957557/
C
      A=-2.2E-7
C
      X1=0.0
      DO 20 J=1,3
      X1=X1*NRPL+XCOEFL(J)
  20  CONTINUE
C
      Y=0.0
      DO 30 N=1,6
      Y=Y*NRPL+YCOEFL(N)
  30  CONTINUE
C
      IF (PSQDELL.GT.X1) GO TO 40
C
      W57LC=Y
      GO TO 45
C
  40  W57LC=A*(PSQDELL-X1)**2.+Y
  45  W57LX=W57LC*DEL(1)/THETA
C
C *** NOTE: THIS CORRELATION GENERATES THE SEA-LEVEL REFERENCED (I.E.
C           CORRECTED) AIRFLOW.  THEREFOR, THE LAST EQUATION ABOVE IS
C           USED TO GENERATED THE PHYSICAL AIRFLOW AT THE COMPRESSOR
C           INLET BASED ON MEASUREMENTS MADE AT PLANE 57.
C
C     RIGHT HAND CMAPS
C
      PSQDELR=PS57R/DEL(2)
C
C     NOTE: PS57R (TURBINE DISCHARGE STATIC PRESSURE) IS INPUT FROM THE CMAPS
C           CONTROLER.
C
      NRPR=(NCPR/78185)*100
C
C
      DATA (XCOEFR(I),I=1,4)/.2041667E-1,-4.4142857,321.74405,-7651.5714/
      DATA (YCOEFR(I),I=1,6)/4.3672014E-9,-1.9017866E-6,3.20077316E-4,
```

```
      1            -2.6095576E-2,1.0498427,-15.96689/
C
       A=-8.1E-7
C
       X1=0.0
       DO 20 J=1,4
       X1=X1*NRPR+XCOEFR(J)
   20  CONTINUE
C
       Y=0.0
       DO 30 N=1,6
       Y=Y*NRPR+YCOEFR(N)
   30  CONTINUE
C
       IF (PSQDELR.GT.X1) GO TO 40
C
       W57RC=Y
       GO TO 45
C
   40  W57RC=A*(PSQDELR-X1)**2.+Y
   45  W57RX=W57RC*DEL(2)/THETA
C
C *** NOTE: THIS CORRELATION GENERATES THE SEA-LEVEL REFERENCED (I.E.
C           CORRECTED) AIRFLOW.  THEREFORE, THE LAST EQUATION ABOVE IS
C           USED TO GENERATED THE PHYSICAL AIRFLOW AT THE COMPRESSOR
C           INLET BASED ON MEASUREMENTS MADE AT PLANE 57.
C
       W57(1)=W57LX
       W57R(1)=W57LC
       W57(2)=W57RX
       W57R(2)=W57RC
C
C  STREAM THRUST AND RAM DRAG CORRECTIONS TO BALANCE OUTPUTS
C
C *** CALCULATE INLET STREAM THRUST AND RAM DRAG USING THE AIRFLOWS
C     CALCULATED FROM THE PLANE 2, PLANE 8, PLANE 15, AND PLANE 57
C     METHODS.
C
C     INLET MACH NUMBER ITERATION SCHEME
C     (GENERIC VERSION FOR ALL FOUR AIRFLOW CALCULATION METHODS)
C
C        INPUTS: COMPRESSOR INLET PHYSICAL AIRFLOW: WX
C                COMPRESSOR FACE AVERAGE TOTAL PRESSURE: PT2X
C                (LEFT OR RIGHT AS APPROPRIATE)
C
       CTR=0
       NX=1.88045*SQRT(TTR)/7.07*(WX/PT2X)
       IF (NX.GT.1.0) GO TO 50
       IF (NX.LT.0.0) GO TO 70
C
```

```
C
      XM5=1-SQRT(1-NX)
   5  NXPRM=1.728*XM5*(1+0.2(XM5)**2)**-3
      ERROR=NX-NXPRM
  10  XM2=1-(1-XM5)*SQRT((1-XN)/(1-NXPRM))
      CTR=CTR+1
      IF (ERROR.LT.0.0001) GO TO 100
      IF (CTR.GT.50) GO TO 100
      XM5=XM2
      GO TO 5
  50  XM2=1.0
      GO TO 100
  70  XM2=0.0
      GO TO 100
C
 100  M=XM2
C
C *** THIS ENDS THE INLET MACH ITERATION ROUTINE ***
C
C   CALCULATE INLET MACH NUMBER FOR EACH OF THE FOUR INLET AIRFLOWS
C   CALCULATED.
C
C  INLET MACH: PLANE 2 METHOD
C
C *** NOTE:   I=1 FOR LEFT HAND INLET
C             I=2 FOR RIGHT HAND INLET
C
      WX=W2(I)
      PT2X=PT2(I)
C
C  APPLY ITERATION ROUTINE
C
      M2(I)=MX
C
C  INLET MACH: PLANE 8 METHOD
C
C *** NOTE:   I=1 FOR LEFT HAND INLET
C             I=2 FOR RIGHT HAND INLET
C
      WX=W8(I)
      PT2X=PT2(I)
C
C  APPLY ITERATION ROUTINE
C
      M8(I)=MX
C
```

304

```
C  INLET MACH: PLANE 15 METHOD
C
C *** NOTE:   I=1 FOR LEFT HAND INLET
C             I=2 FOR RIGHT HAND INLET
C
      WX=W15(I)
      PT2X=PT2(I)
C
C  APPLY ITERATION ROUTINE
C
      M15(I)=MX
C
C  INLET MACH: PLANE 57 METHOD
C
C *** NOTE:   I=1 FOR LEFT HAND INLET
C             I=2 FOR RIGHT HAND INLET
C
      WX=W57(I)
      PT2X=PT2(I)
C
C  APPLY ITERATION ROUTINE
C
      M57(I)=MX
C
C   CALCULATE INLET STATIC PRESSURE BASED ON THE CALCULATED INLET MACH
C
C  INLET STATIC PRESSURE: PLANE 2 METHOD
C
      PS2C(I)=PT2(I)*(1+0.2*(M2(I)**2))**-3.5
C
C  INLET STATIC PRESSURE: PLANE 8 METHOD
C
      PS2C8(I)=PT2(I)*(1+0.2*(M8(I)**2))**-3.5
C
C  INLET STATIC PRESSURE: PLANE 15 METHOD
C
      PS2C15(I)=PT2(I)*(1+0.2*(M15(I)**2))**-3.5
C
C  INLET STATIC PRESSURE: PLANE 57 METHOD
C
      PS2C57(I)=PT2(I)*(1+0.2*(M57(I)**2))**-3.5
C
C   COMPRESSOR STREAM THRUST CALCULATION
C
C     PLANE 2 METHOD
C
      F22=7.07*(PS2C(1)*(1+1.4*M2(1)**2)+PS2C(2)*(1+1.4*M2(2)**2)-2*P0)
C
```

```
C      PLANE 8 METHOD
C
       F28=7.07*(PS2C8(1)*(1+1.4*M8(1)**2)+PS2C8(2)*(1+1.4*M8(2)**2)-2*P0)
C
C      PLANE 15 METHOD
C
       F215=7.07*(PS2C15(1)*(1+1.4*M15(1)**2)+PS2C15(2)*(1+1.4*M15(2)**2)
      1        -2*P0)
C
C      PLANE 57 METHOD
C
       F257=7.07*(PS2C57(1)*(1+1.4*M57(1)**2)+PS2C57(2)*(1+1.4*M57(2)**2)
      1        -2*P0)
C
C
C *** AVERAGE INLET AIRFLOW ***
C
       W2A=(W2(1)+W2(2))/2
C
       W8A=(W8(1)+W8(2))/2
C
       W15A=(W15(1)+W15(2))/2
C
       W57A=(W57(1)+W57(2))/2
C
C
C *** RAM DRAG ***
C
       FRAM2=(-2/32.174)*W2A*V0
C
       FRAM8=(-2/32.174)*W8A*V0
C
       FRAM15=(-2/32.174)*W15A*V0
C
       FRAM57=(-2/32.174)*W57A*V0
C
C *** BALANCE OUTPUT CORRECTION TERMS FOR RAM DRAG AND STREAM THRUST ***
C
C   PLANE 2 METHOD:
C
C   AXIAL FORCE CORRECTION
C
       ABASE2=F22+FRAM2*COS(ALPHAM)
C
C   NORMAL FORCE CORRECTION
C
       NBASE2=FRAM2*SIN(ALPHAM)
C
```

```
C   PLANE 8 METHOD:
C
C   AXIAL FORCE CORRECTION
C
      ABASE8=F28+FRAM8*COS(ALPHAM)
C
C   NORMAL FORCE CORRECTION
C
      NBASE8=FRAM8*SIN(ALPHAM)
C
C   PLANE 15 METHOD:
C
C   AXIAL FORCE CORRECTION
C
      ABASE15=F215+FRAM15*COS(ALPHAM)
C
C   NORMAL FORCE CORRECTION
C
      NBASE15=FRAM15*SIN(ALPHAM)
C
C   PLANE 57 METHOD:
C
C   AXIAL FORCE CORRECTION
C
      ABASE57=F257+FRAM57*COS(ALPHAM)
C
C   NORMAL FORCE CORRECTION
C
      NBASE57=FRAM57*SIN(ALPHAM)
C
C *** FLOW CORRECTION COEFFICIENTS ***
C
C   AXIAL FORCE COEFFICIENT
C
      CDIA2=ABASE2/(Q*5.221)
C
      CDIA8=ABASE8/(Q*5.221)
C
      CDIA15=ABASE15/(Q*5.221)
C
      CDIA57=ABASE57/(Q*5.221)
C
C   NORMAL FORCE COEFFICIENT
C
      CDIN2=NBASE2/(Q*5.221)
C
      CDIN8=NBASE8/(Q*5.221)
C
      CDIN15=NBASE15/(Q*5.221)
C   .
      CDIN57=NBASE57/(Q*5.221)
```

```
C *** WEIGHT TARE CORRECTIONS ***
C
      NWT=-212*(1-COS(ALPHAM))
C
      AWT=-212*(SIN(ALPHAM))
C
      PMWT=-X1*AWT+X2*NWT
C
C *** WHERE X1 AND X2 ARE THE MOMENT ARM LENGTHS FROM MODEL C.G. TO A/C
C     REFERENCE C.G. IN THE AXIAL AND NORMAL DIRECTIONS ***
C
C   BALANCE OUTPUT COEFFICIENTS WITH WEIGHT TARES - BODY AXIS
C
C **** NOTE: THE FOLLOWING TERMS ARE THE DESIGNATIONS USED BY THE NASA
C            AMES DATA REDUCTION PROGRAM FOR THE BALANCE OUTPUTS OF
C            NORMAL FORCE, AXIAL FORCE, AND PITCHING MOMENT:
C                  .EX-TARE.N(1)
C                  .EX-TARE.A(1)
C                  .EX-TARE.PM(1)
C
      CNUC=((.EX-TARE.N(1))+NWT)/(Q*5.221)
C
      CAUC=((.EX-TARE.A(1))+AWT)/(Q*5.221)
C
      CMUC=((.EX-TARE.PM(1))+PMWT)/(Q*5.221*1.368)
C
C   BALANCE OUTPUT COEFFICIENTS WITH WEIGHT TARES - STABILITY AXIS
C
      CLUC=CNUC*COS(ALPHAM)-CAUC*SIN(ALPHAM)
C
      CDUC=CAUC*COS(ALPHAM)+CNUC*SIN(ALPHAM)
C
C   AIRFRAME COEFFICIENTS - BODY AXIS
C
C      WITH FLOW CORRECTIONS BASED ON PLANE 2 METHOD
C
      CNFA2=CNUC+NCAVN+CDIN2
C
      CAFA2=CAUC+ACAVN+CDIA2
C
      CMNA2=CMUC+PMCAVN
C
C      WITH FLOW CORRECTIONS BASED ON PLANE 8 METHOD
C
      CNFA8=CNUC+NCAVN+CDIN8
C
      CAFA8=CAUC+ACAVN+CDIA8
C
      CMNA8=CMUC+PMCAVN
C
```

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```
C          WITH FLOW CORRECTIONS BASED ON PLANE 15 METHOD
C
C      CNFA15=CNUC+NCAVN+CDIN15
C
C      CAFA15=CAUC+ACAVN+CDIA15
C
C      CMNA15=CMUC+PMCAVN
C
C          WITH FLOW CORRECTIONS BASED ON PLANE 57 METHOD
C
C      CNFA57=CNUC+NCAVN+CDIN57
C
C      CAFA57=CAUC+ACAVN+CDIA57
C
C      CMNA57=CMUC+PMCAVN
C
C  AIRFRAME COEFFICIENTS - STABILITY AXIS
C
C          WITH FLOW CORRECTIONS BASED ON PLANE 2 METHOD
C
C      CLA2=CNFA2*COS(ALPHAM)-CAFA2*SIN(ALPHAM)
C
C      CDA2=CAFA2*COS(ALPHAM)+CNFA2*SIN(ALPHAM)
C
C      CLASQ2=CLA2*ABS(CLA2)
C
C          WITH FLOW CORRECTIONS BASED ON PLANE 8 METHOD
C
C      CLA8=CNFA8*COS(ALPHAM)-CAFA8*SIN(ALPHAM)
C
C      CDA8=CAFA8*COS(ALPHAM)+CNFA8*SIN(ALPHAM)
C
C      CLASQ8=CLA8*ABS(CLA8)
C
C          WITH FLOW CORRECTIONS BASED ON PLANE 15 METHOD
C
C      CLA15=CNFA15*COS(ALPHAM)-CAFA15*SIN(ALPHAM)
C
C      CDA15=CAFA15*COS(ALPHAM)+CNFA15*SIN(ALPHAM)
C
C      CLASQ15=CLA15*ABS(CLA15)
C
C          WITH FLOW CORRECTIONS BASED ON PLANE 57 METHOD
C
C      CLA57=CNFA57*COS(ALPHAM)-CAFA57*SIN(ALPHAM)
C
C      CDA57=CAFA57*COS(ALPHAM)+CNFA57*SIN(ALPHAM)
C
C      CLASQ57=CLA57*ABS(CLA57)
C
```

```
C    TOTAL AIRCRAFT (AIRFRAME+NOZZLES) STABILITY AXIS COEFFICIENTS
C
C        PLANE 2 METHOD
C
C        CL2=CLA2+CLN
C
C        CD2=CDA2+CDN
C
C        CDAROTF2=CDA2+CDARONF
C
C        CM2=CMNA2+CPMN
C
C        CLSQ2=CL2*ABS(CL2)
C
C        PLANE 8 METHOD
C
C        CL8=CLA8+CLN
C
C        CD8=CDA8+CDN
C
C        CDAROTF8=CDA8+CDARONF
C
C        CM8=CMNA8+CPMN
C
C        CLSQ8=CL8*ABS(CL8)
C
C        PLANE 15 METHOD
C
C        CL15=CLA15+CLN
C
C        CD15=CDA15+CDN
C
C        CDAROTF15=CDA15+CDARONF
C
C        CM15=CMNA15+CPMN
C
C        CLSQ15=CL15*ABS(CL15)
C
C        PLANE 57 METHOD
C
C        CL57=CLA57+CLN
C
C        CD57=CDA57+CDN
C
C        CDAROTF57=CDA57+CDARONF
C
C        CM57=CMNA57+CPMN
C
C        CLSQ57=CL57*ABS(CL57)
C
C    *** NOTE: THE COEFFICIENTS FROM THE PLANE 8 METHOD WERE CHOSEN AS THE
```

```
C                    PRIMARY PARAMETERS IN THE CONVENTIONAL MODE ANALYSIS. THE
C                    PLANE 57 COEFFICIENTS WERE USED IN THE CMAPS ANALYSIS.
C
C *** CAPTURE AREA RATIO (MASS FLOW RATIO) ***
C
      MDOT=SQRT(0.9443*XMO**2+0.1688*XMO**4)
C
C             NOTE:   I=1 FOR LEFT HAND INLET
C                     I=2 FOR RIGHT HAND INLET
C
      AO2(I)=(W2(I)*SQRT(TTR))/(PO*MDOT)
C
      AO8(I)=(W8(I)*SQRT(TTR))/(PO*MDOT)
C
      AO15(I)=(W15(I)*SQRT(TTR))/(PO*MDOT)
C
      AO57(I)=(W57(I)*SQRT(TTR))/(PO*MDOT)
C
C  CAPTURE AREA RATIO CALCULATION
C
      CAP2(I)=AO2(I)/5.46
C
      CAP8(I)=AO8(I)/5.46
C
      CAP15(I)=AO15(I)/5.46
C
      CAP57(I)=AO57(I)/5.46
C
C *** NOTE: THE PLANE 8 MFR WAS THE PARAMETER USED FOR THE FLOW-THROUGH
C             MODE. THE PLANE 57 MFR WAS USED FOR THE CMAPS ANALYSIS.
C
C *** NOZZLE PRESSURE RATIO CALCULATION ***
C
C NOZZLE TOTAL PRESSURE INSTRUMENTATION FAILURES DURING THE JET-EFFECTS
C AND CMAPS MODES TESTING NECESSITATED THE FOLLOWING SCHEME OF
C CALCULATING NOZZLE TOTAL PRESSURE FROM THE TOTAL AIRFLOW THROUGH THE
C NOZZLE.  THE TEXT IN SECTION 3.0 OF THIS REPORT FURTHER DESCRIBES THE
C PROCESS.
C
C   *** JET-EFFECTS MODE ***
C
C
      W8(I)=WDV(I)+WMIX(I)
C
      NPR(I)=(W8(I)*SQRT(TT7(I)))/(PO*ALL*0.505)
C
C ALL=THROAT AREA OF THE ALBEN DEPENDING ON POWER SETTING AND VECTOR
C ANGLE
C
```

```
C *** CMAPS MODE ONLY ***
C
      WJF(I)=W57(I)+WDV(I)-WBV(I)
C
C   THE FOLLOWING ITERATION SCHEME IS USED TO CALCULATE NPR BASED ON WJF
C
      TERM=(WJF(I)*SQRT(TT7))/(P0*5.151)
      NPRX(1)=TERM/0.5150
      J=0
 05   J=J+1
C
      IF (NPRX(J).LT.1.01) GO TO 10
      IF (NPRX(J).LE.1.50) GO TO 30
C
      TAP(J)=0.5150
      GO TO 50
C
 10   TAP(J)=0.3000
      GO TO 50
C
 30   TAP(J)=-7.7494+16.7138*NPRX(J)-11.2561*NPRX(J)**2+2.5231*NPRX(J)**3
C
 50   NPRX(J+1)=TERM/TAP(J)
C
      TEST=ABS((NPRX(J+1)-NPRX(J))/NPRX(J+1))
C
      IF (TEST.LT.0.001) GO TO 100
      GO TO 05
C
 100  NPR(I)=NPRX(J+1)
C
      NPRA=(NPR(1)+NPR(2))/2
C
      EPR(I)=NPR(I)*P0/PT2(I)
C
```

This concludes the list of data reduction equations for the three test modes.

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15. Supplementary Notes

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16. Abstract

A wind tunnel model of a supersonic V/STOL fighter configuration has been
tested to measure the aerodynamic interaction effects which can result from
geometrically close-coupled propulsion system/airframe components. The
approach was to configure the model to represent two different test techniques.
One was a conventional test technique composed of two test modes. In the
Flow-Through mode, absolute configuration aerodynamics are measured, including
inlet/airframe interactions. In the Jet-Effects mode, incremental nozzle/
airframe interactions are measured. The other test technique is a propulsion
simulator approach, where a sub-scale, externally powered engine is mounted
in the model. This allows proper measurement of inlet/airframe and nozzle/
airframe interactions simultaneously.

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